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THE

PHENOMENA

AND

ORDER

OF THE

SOLAR SYSTEM.

BY

J. P. NICHOL, LL.D., F.R.S.E.,

PROFESSOR OF PRACTICAL ASTRONOMY IN THE UNIVERSITY OF GLASGOW: AUTHOR OF "VIEWS OF THE ARCHITECTURE OF THE HEAVENS, &C."

FROM THE LAST EDINBURGH EDITION.

ILLUSTRATED WITH PLATES.

NEW-YORK:
PUBLISHED BY DAYTON & NEWMAN,
No. 199 Broadway.
1842.

MU

TO

LIEUTENANT-GENERAL

SIR THOMAS MACDOUGALL BRISBANE, BART. K.G.C.B.

&c. &c. &c.

CORRESPONDING MEMBER OF THE INSTITUTE OF FRANCE,

FOUNDER OF THE OBSERVATORY OF PARAMATTA,

THIS VOLUME

IS

RESPECTFULLY INSCRIBED.

Gift
Tappan Presb. Ass
12-15-1931

NOTE.

The volume now presented to the public owes its existence to a suggestion by my publisher. Having discerned that a work on our own planetary scheme of something of the character of the "Architecture of the Heavens," might be useful, he requested my attention to the subject; and I have accordingly endeavored to produce what, I trust, will be found worthy of a portion of the forbearance so liberally extended to my former treatise. Very far from attempting to write everything which can possibly be said on this subject, I have selected and dwelt only on its salient points; being desirous of not fatiguing the general reader, for whom the work is destined. That I might present, besides, Astronomy as a moral monument or phenomenon, or as one index of the mode of Man's intercourse with the external Universe, I have traced it from its birth: nor although the method thus adopted, has unfortunately thrown a degree of abstruseness and common-place detail into the first chapters, am I without hopes that it may be instructive.

In the present volume, there is less of minute correspondence with the "Architecture of the Heavens," than could be wished in two parts of one work—a discrepancy arising from the fact, that this which is the natural predecessor of the former volume, was composed after it..

As it now stands, I beg to present it as Vol. I. of the Series elsewhere announced.

College, Glasgow,
29th July, 1838.

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PART I.

THE MOTIONS OF THE PLANETARY ORBS.

INTRODUCTION.

THAT feature of the Heavens which first strikes the untutored Observer after he has ceased to wonder at their mere brilliancy, is the prevalence of *motion* and activity—in some cases general and uniform, in others special and intricate; and curiosity impels him to examine more closely, that so he may unravel the order and significancy of the vast and remarkable changes which meet his view. Precisely thus, Astronomy arose in the World; and the course of its history marks that gradual acquisition of knowledge, that proneness to hasty conclusion, and that slow and laborious purification and enlargement of early and narrow ideas, which may still be supposed to characterize the progress of an individual mind, endeavoring to ascend from the outward aspect of the skies, to the profound laws expressive of the harmony of their arrangements. Happily, this easy and natural rise of our Science has allowed me, while unfolding its truths, also to notice its course: and if I sometimes dwell with fondness, on the actions, character, and fates of the Heroes of its history, those men who created it by successive conquests over the unknown,—I am sure I introduce no discordant consideration, for they also are STARS; and we are drawn nearer the ETERNAL by the memory of their greatness.

CHAPTER I.

THE EARLY ASTRONOMY.

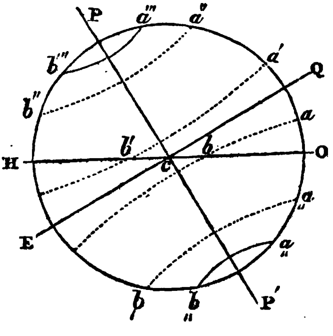
Looking far into past time, and to those countries where western thought was cradled, we find precise and interesting conceptions of the chief motions of the stars: and as man is impelled by a wholesome necessity of his nature, to collect, classify, and systematize the objects of his thoughts,—the period of the acquisition of these conceptions was rapidly followed by an epoch of theory, giving birth to elaborate schemes of the Heavens, which all bore such emphatic marks of the infancy of reflection, as invariably characterize our first endeavors to comprehend any portion of Nature. Accordingly, this chapter must consist of two sections—the first, unfolding the *facts* known to the ancients; and the second the system or scheme into which these were immediately wrought up.

§ 1.

The facts recognized by the Chaldeans and so many other nations, that they may be termed the common stock of antiquity, are three in number. Doubtless, they are familiar to all I now address, but as Astronomical *theory*, arose altogether out of them, I am compelled to detail them with perhaps tedious precision.

1. The observer of the skies is soon arrested by two

prominent appearances,—the existence of regular and uniform motion among the shining hosts, and also their wonderful *internal* stability. The stars which emerge as the effulgence of the sun declines, are arranged configurations from which they never deviate; not one star (with the few exceptions I shall soon notice) becomes more or less distant from another, although watched for many nights—the group of the Great Bear, for instance, never altering its form; nor would displacement or internal motion be recognized by the eye could we prolong the examination through ages. These bodies are indeed FIXED *in regard of each other;* but they also partake of a grand and imposing common motion. Appearing in the east, in the established order of their positions, they ascend in the Heavens as the night passes, as if some wonderful scroll were being unrolled; and having attained their greatest height in the sky, sink again like the sun, and disappear in the west. The whole phenomena and peculiarities of these remarkable motions, may be rendered palpable by means of a simple diagram. Let the indefinite H O represent the *horizon* —that apparently flat plain around us, which is the bound-



ing line of vision: suppose, also, that the plain is surrounded by a large hollow globe or sphere, E P Q P′, whose centre is *c*, and on whose inner surface we may imagine that the fixed stars are placed. Now, if that sphere revolve upon its axis P P′ from east to west, the stars will be carried in settled order along with it; each star will *rise* or be first seen by the spectator at *c*, the instant it ascends above the line or plane H O, and *set* when it sinks as far as the western side; and none will be visible unless during that part of their circular revolution which is *above* the horizon or bounding line. Moreover, the position of the axis P P′ of the sphere relative to H O, will explain why the visible paths of the different stars are so different as they are seen to be in length and elevation. The star *a*, for instance, will be visible only during its motion through *ab*—a comparatively small part of its entire course; the star *a′*, on the other hand, will be seen while moving through the whole of the larger arch *a′b′*, and at *a′*, the middle point of its course, it will reach much higher in the heavens than *a*. It will be observed, likewise, why stars in position *a″ a‴* never set, in the true sense of the term; that is why they never sink below the line H O, and why, but for that superior light which effaces them at sunrise, they would be seen wheeling constantly through entire circles around the fixed point P,* hence termed the *pole* of the Heavens.† The exact correspondence of what an observer notes in the

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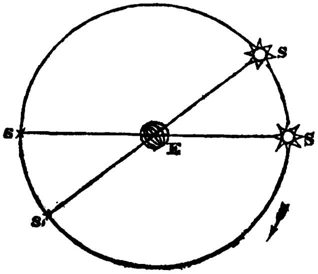
[*] These stars *are* seen in the day time through a telescope. It requires only a moderate instrument to detect the brightest of them.

[†] The line H O, as has been indicated, is termed the *Horizon*. P P′ the line passing through the poles of the sphere is the *axis*. E Q the line or great circle running through the Heavens, equidistant from P and P′, is the *Equator*. All these lines, and, indeed, the whole diagrams and reasonings on this subject will be better understood by referring to a globe.

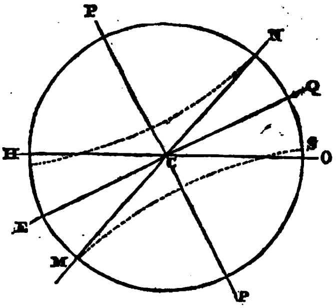
sky, with this simple mode of representation, assisted by the illusion which inclines us to term the Heavens a *vault*, impressed the early inquirers with the belief that such a sphere actually exists—a sphere named in consequence, *the sphere of the fixed stars*, and whose daily majestic rotation upon its axis was designated *the diurnal revolution of the sphere.* More advanced astronomy has clearly demonstrated that this revolution is not real but apparent only—the stars being fixed in their own solitudes; and if, notwithstanding that we know it to be illusion, even *we* cannot look on it in a peaceful night without some emotion—so solemn is it, so ceaseless and noiseless—how powerfully must the belief of its reality have, in those ages, operated on men's minds, and how wonderful and profound the revelation it must have brought concerning the more hidden nature of the Universe! In those days, no law had yet comprehended the course of the events of the Earth; its changes appeared to flow from the irregular will of conflicting deities and demons; and man, bewildered and distracted, might have lain down in despair, deeming himself the victim of unintelligible caprice, had not the Heavens proclaimed so early, at once the reality and the supremacy of Order—the existence of a still Power in far infinity superior to terrestrial lawlessness, and typified by the majesty, harmony, and repose of the mightiest phenomena of Nature.

2. Of the few bodies which do not partake of the fixity of the other stars, and which vary their position according to courses of their own, the SUN and the MOON are the most brilliant, and in all respects the most noticeable; so that their paths and changes were naturally remarked in primitive times. This constant change of place among the fixed stars is more easily observed in the case of the MOON than of the SUN. The effulgence of the latter orb effaces

the lustre of all minor bodies so long as he is above the horizon, and thus blots out as it were those fixed points in reference to which we might trace his course—that of the Moon, on the other hand, only effacing the light of the smaller stars, and still leaving in view numerous bodies with which we may compare her place. Now, suppose that on any night the Moon is close to Aldebaran—that bright star in the Bull's-Eye,—next night she will be found to have fallen considerably *behind* Aldebaran, *i. e.* she will not rise until some time after it; after another such interval, her distance from this star will appear still greater, and she will continue to recede gradually but unremittingly until she perform the entire circuit of the Heavens,—returning nearly to her former proximity to Aldebaran, after the lapse of a month. Using the phraseology of the early astronomers, it thus appears that while the Moon, like all the celestial bodies, is carried daily round the Earth by the sphere of the fixed stars—a motion which causes her rising and setting, she has also a sphere or circle of her own which carries her slowly in the opposite direction, making her move through the Heavens in one month, and thus measure a fixed and certain epoch of time. For the reason assigned the path of the Sun is not *immediately* discernible, but it can be determined on grounds equal-



ly sure. Suppose the earth at E, and S the place of the Sun in the sphere of the Fixed Stars;—inasmuch as he reaches the middle of his diurnal path in his greatest height at noon, the star *s* opposite to him will reach the middle point of its course precisely at midnight, and were the Sun's position invariable, the same star or constellation at midnight would be *always* at its highest point or *culmination.* But the most cursory observation shows that this is not the case, for one-half of the whole Heavens would then be constantly veiled from us—shrouded by the solar rays; whereas, as the year advances, different portions of the spangling panorama are unfolded, at the close of that period we may have surveyed the whole. It is easy to discover the nature of this annual motion of the Sun to which we owe our acquaintance with the entire sky. If the sphere of the Fixed Stars, as represented in the foregoing wood-cut by the circle, revolve in the direction of the arrow, and if the Sun at noon on one day be at S, then as I have said, the star *s*, directly opposite, will be found at its highest point, or at the middle of its course, at midnight; and if on the subsequent evening *s* have passed the middle of its path some time previous to midnight, and the star *s'* become the culminating or presiding luminary at that hour, the Sun must now be opposite *s'*—in other words, *he will have moved from S to S'*. Tracing him by these infallible marks, we ascertain that he moves through the whole Heavens regularly in *one year*—thus fixing the largest unit of terrestrial time; so that—still employing the language of the early astronomy—it appears that besides being carried daily around us by the sphere of the Fixed Stars, this great luminary has, like the Moon, a sphere or circle of his own, which carries him in the opposite direction regularly through his annual course among the departments of the Heavens. The Sun's proper circle or path has one most important attribute: it is not along the celestial equator, nor in the same direction with it, but in a line cutting that equator—one half being above and the other below it; thus, if E Q be the celestial equator, or the great circle half-way between the Poles of the sphere of the Fixed Stars, the annual course of the Sun is along an oblique line, such as M N. Now this oblique disposition of the route of our luminary originates very remarkable phenomena. When, for instance, the Sun is in that part of his orbit farthest above the equator, his place at noon, or at the middle of his *diurnal* path, will be at N, or at a considerable height above the horizon; while at the time of the year during which he is moving through the lowest part of his orbit, his mid-day altitude will be no greater than that of the point S.[*] But it is plain that these different elevations will very much affect the degree of heat communicated by the Sun's rays to the Earth at



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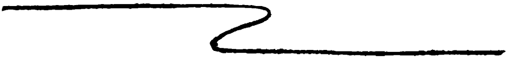
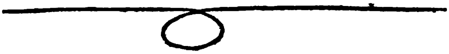
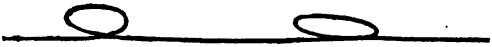
[*] The higher the Sun reaches, the longer evidently is his *visible arch*. Hence his different positions in this orbit, will cause varying lengths of days and nights at different seasons of the year. . . The Sun's path, it may be mentioned, is termed the *Ecliptic*.

C, insomuch that when he is *low*, the rays will start off, producing comparatively little effect, whereas his position at N must enable him to communicate to the inhabitants at C a much fuller portion of his beneficence. Hence the phenomena of the SEASONS—phenomena *strictly dependent on the annual course of the Sun.* The ancients early recognized this great truth. They saw that, as well as the usual day and night of the world—the day and night of the world's year, through which plants spring, grow, ripen, and die, and by which man's larger activities are ordered, and his prudence and calculation extended over a wider space—all issue from the movements of this mighty orb: and why wonder if they who lived in our race's infancy descried in a connection so close and marvellous, seeming presumptions that the Sun might be a peculiar seat of divinity, and wrought up the phenomena of his course into mystic and elaborate mythologies? Here, too, I doubt not, originated the curious fabric of Judicial Astrology—a superstition hollow and deceiving, but which like all superstitions was recommended and upheld by its inspiring appeals to the nobler parts of man's nature. It is not true, as often said, that Astrology was the mother of Astronomy, nor would the fact, even were it so, give the false parent any great claim to regard; but I think we may see in it the first and most daring expression of the human mind of its belief in the existence of a wide and permanent sympathy through all things, and also the first distinct outburst of the ambition of man—a wild but grand effort to break from the bondage of disorder, and to unite his destiny and being with these far and noble orbs. How beneficent is the Universe! If these stars had not shone on mankind even even when we understood them not, many a heavenward thought had never been born; or the aspiration, faint and weak, had struck when it arose against the close roof of the world, sunk back to the ground and been enclosed as in a tomb for ever!

3. It was soon detected that the SUN and MOON, although performing courses through the Heavens in fixed times, do not move with regular or uniform celerity throughout these courses; *i. e.* at one season of the year, the Sun, for instance, moves more rapidly among the stars than at another, and so much more of the MOON; but the irregularities of these bodies are comparatively trifling, compared with those which characterize the motion of other and smaller though still very conspicuous objects. The ancients were aware of the existence of other five celestial bodies, MERCURY, VENUS, MARS, JUPITER, and SATURN, which—although also carried round by the diurnal revolution of the sphere, and therefore rising and setting as the other stars—have, like the Sun and Moon, spheres of their own, carrying them in the main, in a direction contrary to that of the motion of the starry sphere. I say expressly, *in the main*, for not only is the celerity of these planets in their proper courses, irregular as those of the Sun and Moon are; but they often even *change their directions*, moving in that case *along with* the diurnal sphere but quicker than it moves, and describing among the fixed stars courses as singular as the lines below;—the star







often retrograding, or going backwards, and frequently performing a looped course. In more accurate and especial illustration of these curious facts, Plate I. contains a view of the paths of these planets for the year 1838.* Intimately connected with the course of the Sun, never departing from it by more than a trifling quantity—how irregular these paths are; how arduous the attempt to reduce them within law—to show that those loops and twistings are only other and more various exemplifications of that harmony which characterizes the great revolution of the stars! Most fortunate that the problem fell to be undertaken by a people whom no difficulties could daunt, whose fresh and elastic minds no resistance could repel,—that it came to be stirred in a country where no inquirer ever laid aside the feeling so well expressed by one of its greatest philosophers—that no Greek should think it unfitting to examine closely the conduct of the Divinities, but consider on the contrary these Powers as never acting without design, and that, knowing man's nature, they so act that he may understand and be guided by the instruction afforded him by events. Thanks to the profound Athenian who thus spoke: and because Providence produced a race of men who could think so, and who, amid all their ignorance and failures, felt this truth as an indwelling impulse—no civilized nation can ever exist which will not gratefully trace back the germ of much of its intellectual manhood to the isles and old headlands of the Egean.†

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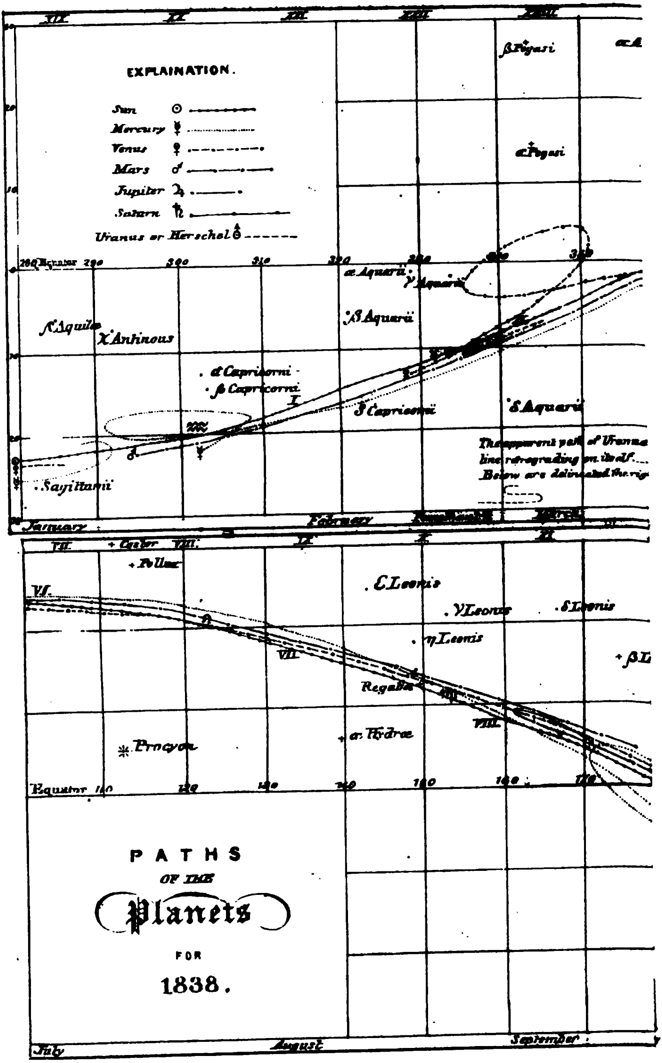
* Copied from an elaborate chart by a German Astronomer. The lower part of the plate joins the upper part on the *right*.

† The Ancients were besides acquainted with the shape of the Earth, viz. that it is *round*; they knew also the causes of eclipses, &c.



PATHS

OF THE

Planets

FOR

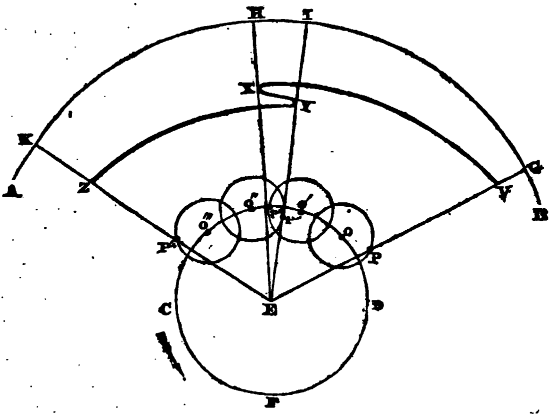
1838.

UNIV. OF MICH.

§ 2.

We owe the first theory of these three classes of motion, or the first system into which they were wrought up, to the Greeks; and the scheme they imagined exercised most important influence over the future course of Astronomy, although characterized by all the errors attendant on early attempts at generalization. It is almost a universal fact, that no observer in the first instance ever dreams that the appearances on which he is theorizing, are not in their *absolute* shape and form precisely *as he sees them*: no doubt is ever suggested that any thing in the phenomena may be owing to peculiarity in the position from which he looks at them; and under such delusion, these earlier theorists never suspected that any portion of the motions apparently proceeding around them, could arise from the peculiarities of the World on which they stood, viz. *from the motion of the Earth.* They adopted, therefore, as a first and fundamental tenet, the proposition that *the Earth is the centre of the Universe and at rest*; to which they added another maxim, *that the celestial orbs must all move in perfect circles and with an uniform motion*; two suppositions which for many ages were considered to belong essentially to that class of beliefs which are not deemed liable even to the *possibility* of doubt. The reconcilement of the motion of the sphere of the Fixed Stars, to these most narrow dogmas, presented no difficulty whatever: for of that celestial sphere, the Earth seems exactly the centre, and no machine ever imagined by man can equal the precision and evenness of its course. But the task began when they looked to the irregular proper motion of the sun and moon, and the singular courses of the planets: and certainly the artifice by which the Greeks overcame this difficulty, and surmounted the barrier, placed by the falsity of their first principles, to any advance, in the science of the Heavens, must ever be accounted happy and ingenious. It struck them very early, *that any motion, however irregular, might be conceived to be produced by the combination of various uniforn motions ;* and therefore that the courses of the planets, tortuous as they seem, might still be resolved *by a combination of uniform circular motions*, and reduced within dominion of their second cardinal maxim. In illustration, suppose that a ship were sailing evenly and uniformly along a coast; it is manifest that a passenger standing on deck, would appear to a spectator on shore to move past him also in a regulated and uniform manner—with the same velocity as the ship; but if, instead of standing, the passenger should walk to and fro on the vessel's deck, likewise with a constant pace—his actual motion along the coast would clearly seem of the most irregular kind. While walking from stern to prow his motion would appear *faster* than the ship's: and when walking from prow to stern, it would, on the contrary, appear *slower ;* nay, if in this latter case, the passenger walked faster than the ship sailed, he would appear *to go for a certain time along the coast the other way :* so that if the vessel were invisible, and the observer fixed his attention solely on the passenger, he would see very irregular motions—sometimes *accelerated*, sometimes *retarded*, sometimes even *retrograde*—all, however, flowing from the mere combination of *two uniform motions*, the sailing of the vessel and the walking of the passenger. It is not difficult to transfer this principle to the case of circular motion as the accompanying diagram will shew. Suppose the great arch A B to be part of the sphere of the fixed stars, the Earth E being its centre, and let C F D O be the proper circle or sphere of a planet;

but instead of fancying that the planet is placed in the circumference of the circle or sphere, let it be placed in the circumference of another smaller circle, whose centre O O' O'' O''' moves uniformly around the great circle

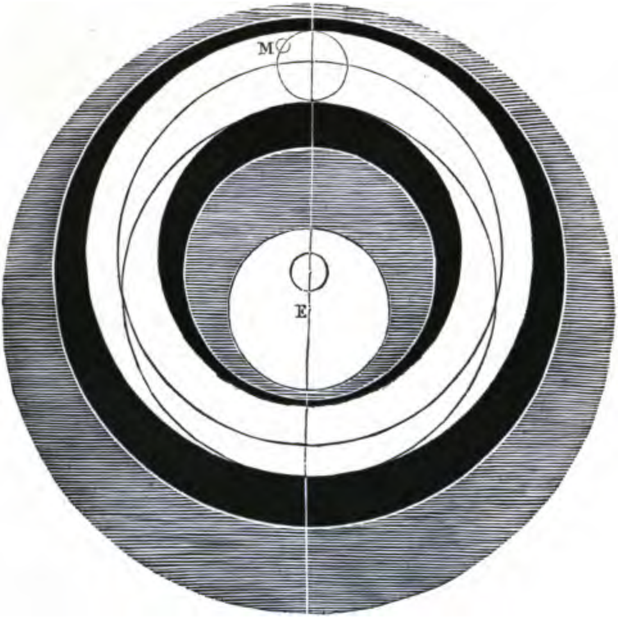


C F D O in the direction of the arrow. Now, whether the small circle has any motion around its own centre or not, it is clear that the main or principle motion of the planet will, in such circumstances, be around the great circle C F D O, or through the whole Heaven of the fixed stars in a definite time; but if all the while the small circle is likewise *whirling around its own centre*, and carrying the planet along with it also through this second motion, we may then be certain of such apparent irregularities in the velocities, &c. of that body, as supervened in consequence of the passenger walking backwards and forwards on his vessel's deck. For instance, suppose the centre of the small circle to be at four successive moments at the points O, O′ O″ O‴, and that owing to the circle's own regular revolution *around its centre* in the direction of the arrow, the planet's places on its circumference are at these times at P, P′ P″ P‴,—the position of the planet among the fixed stars will, at these same moments, seem to be along the lines EG, EH, EI, EK, so that between the times when the centre of the planet's circle was at O′ and O″ it would appear to the spectator on the Earth to have gone back among the stars; and during the whole interval referred to (at the same time without any *real* breach of the principle of uniform circular motion) to have passed over the irregular and twisted course V X Y Z. Now, as such irregularities more or less affect every planet, it may already be conceived that the chart usually given of the ancient astronomy—in which the Earth as the centre, is surrounded by one circle for each planet—conveys no idea whatever of its singular structure: for around each of these circles, the centres of others, whirling with their own velocities, ought to be revolving; and even the large circles themselves often had their centres not in the Earth, but in the circumference of other subordinates, of which the Earth occupied the middle point! The artifice, it will be seen too, is most prolific, and capable of being carried to almost any extent; for always as the course of discovery unfolded new irregularities in the planetary motions, the theorist was prepared to resolve them by the introduction of other circles, or by adding more wheels to the complex machine. Surveying the extravagant intricacy wherewith, in the course of time, this system invested the planetary motions, we are prone to wonder why its cultivators, with so much ingenuity, yet failed so signally in judgment—why the acuteness which constructed and adapted so unlikely a machinery, never thought of *questioning the truth of those two dogmas on which* *the system reposed*, and which necessitated its fallacies and cumbrousness? But if we look at human nature and consult experience, it will be found that the inquiry into First Principles, or even the proposal to search out the root of reigning axioms and ideas, is the very highest and rarest exercise of thought. The energies of the mass of mankind are expended in examining the *interior* relations of the systems within which we are born, and in perfecting the consistency of their parts; and it is only one or two minds in a long age which dream of stepping beyond the straight circle described around them by the times in which they live. Conviction in the first principles of this complex celestial mechanism lay unquestioned for centuries —an hereditary bondage upon the intellect of man: it was destroyed only at the expense of illustrious victims, and all baseless as it now seems, the epoch of all its merit, to be accounted an era in the course of social regeneration.

The history of the progress downwards of this system of the Heavens, or of its gradual descent from an early comparative simplicity, into deeper and most irrational extravagance, is marked by circumstances which ought not to be forgotten. Completed during the reigns of Adrian and Antonine at Rome, by Hipparchus and Ptolemy of Alexandria—the first the greatest observer of ancient times, and the latter the first scholar and best writer of the school he adorned—the PTOLEMAIC SYSTEM (for thus by common consent has it been designated) did not, as it first came from the mint of these original minds, appear to involve even the supposition of the *reality* of the multitudes of circles with which it crowded the sky, but only *assumed their existence*, as affording the easiest means, in that early state of mathematical science, of grouping the observed facts into manageable forms, so that the positions of the planets might thereby be calculated and foreseen: and had the legacy fallen to men worthy to receive it, it might have grown with ease into purer knowledge: while its sound essence —its large comprehension of phenomena had been cherished, the form would have been altered and expanded according to convenience and events; nor would its living body, after waxing, and approaching the stature of manhood, have been ruthlessly compressed within the unsuitable garments of its youth. But unfortunately there was no Ptolemy or Hipparchus to receive this system from its creators. As has happened to most great men—these illustrious persons were succeeded by a herd of mean and slavish minds, anxious rather to obtain distinction and notoriety by being accounted followers of Ptolemy, than to do Ptolemy honor by imitating his high love of truth. The technicalities of the system—which they who call themselves the disciples of a great man, most easily understand —became thus as sacred as its essence; and that which Ptolemy himself would doubtless have soon repudiated— over which his fine and advancing genius would assuredly have arisen, was fastened to his name for ever, by persons who did him the disservice to make him head of a sect. Before astronomy quitted Alexandria these various and complex circles had become—no longer supposititious—no longer a hypothetical though useful, machinery, but real and substantial as the planets themselves: and when we reach the dull and dismal flat of the middle ages—whose character was the absence of originality, the activity of the learned or commentatorial spirit, along with much acuteness and acerbity in logic, the system of these later Alexandrians is largely increased in extravagance. As already referred to, some of the early Greeks had spoken

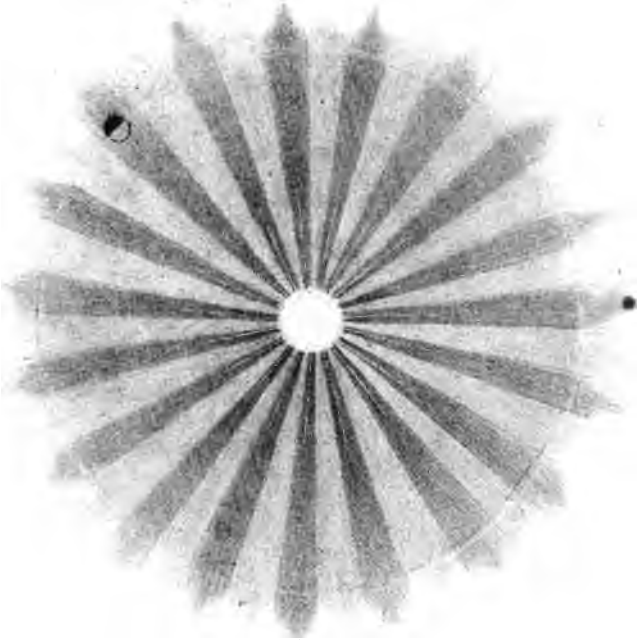
Pl II.

THE
PERFECTION OF LOGIC.



THE

SIMPLICITY OF TRUTH



of the fixed stars being placed in a crystalline sphere, and made a few general remarks upon the spheres of the other stars; whereupon the philosophers of the middle ages, not contented with the belief that Ptolemy's circles were actual existences, and to be found in space—converted each of them into a *sphere or globe of crystal*—crystal, however, which had the heavenly property of being indestructible; for these globes revolved among and through each other without fracture or jar! Nor was this all:—Spirit of Ptolemy, be not disturbed by the folly of mortals!—the observations of the Arabians and some Europeans had by that time (for now nearly thirteen hundred years had passed since the death of the founder of this system) accumulated facts which unfolded new and very varied irregularities among the stars; and forthwith logic set again to work—the false fundamental maxims broke not, and bent not under their new load—fresh crystalline spheres were most liberally created, and preserved from destruction by apotheosis. *Jerome Fracastor* considered that he could still include all the wanderings of the stars, provided the solar system were composed of ninety-six spheres of crystal; and, with meritorious candor, he tells us that the scheme is not his own, but one which he received from a young friend on his deathbed, who solemnly left him charge of this claim to immortal renown! But the grand reconciler was *George Purbach*, whose work, talented and acute, on *New Theories of the Planets*, is, I believe, one of the most singular productions of the sane intellect of man. I much desired to exhibit, on one sheet, Purbach's view of the entire planetary system, but the necessary dimensions of the chart deterred me, after trial, from the attempt. That his merits, however, may not be wholly obscured, look at Plate II: it is his scheme for the motions of Mercury; each color representing a different crystalline sphere; the Earth being at E, and the Planet on the surface of the small sphere within the white eccentric ring! On the opposite page, that simple line encircling the Sun is Mercury's true path: and remembering that the Ptolemaist's scheme nearly represented all Mercury's apparent motions—that it showed how a most false and grotesque scheme could yet be forced into some simulation of truth—say, in candor, whether the genius of Purbach is not worthy of a peculiar renown, and whether in reality there is not a portentous power in *Logic!*

I have read the "Theories" of Purbach, but shall never be so venturous again. His multitudes of ever-wheeling crystalline spheres, produce in one's head an unwholesome buzz,—reminding me of the complaint of the student in Faust,

> "Within my brain I hear a sound
> Of fifty mill-wheels whirling round;"

although in the times when he wrote, men's heads must have been stronger, as all Europe applauded his achievements, and termed him her first astronomer: by his work, King Alphonso's sneers, and the half doubts of stray infidels, were silenced, utterly and for ever; sedition was quashed, doubt annihilated, and the heavens of Ptolemy demonstrated impregnable and eternal!

The chapter of the history of the human mind,—for such too, is this fundamental chapter of Astronomy,—over which we have cast a rapid glance, contains much to warn, but also something to encourage hope. In the long endurance of a system like that which Ptolemy's became, have we not an emphatic indication of the nature of the destiny of man upon the earth? With the world as with the individual, truth is to be attained only and slowly, by labor; and it seems as if knowledge and perfection cannot be reached unless through struggle. The contemplation of these drawn out toils of humanity, so far from being dispiriting, is the prognostic of all good. If we have risen far, it is a pledge that we shall rise still farther. To penetrate more into the august temple of the Universe is not now denied to men of devout spirit, even as we have fought victoriously with strong and compact ignorance, before. Grand those visions—arranging, harmonizing, elevating those truths which will reach us when mists now dimming our eyes are cleared away—obscurations which will not always lie over our own world, and which, it is humbly and reverently hoped, will at least be partially withdrawn from all minds desirous of knowledge and of good, when they pass that mysterious crisis of being which removes them from participation in the existing and visible course of affairs.

CHAPTER II.

THE REFORM OF ASTRONOMY.

§ 1. *Copernicus.*

In the history of Systems, the hour of triumph is often the hour of fall. When logic has done its uttermost, and ingenuity made successful use of every artifice to prove that natural which is not so, some remote or obscure mind, less than usual under the thraldom of custom, and, it may be, gifted by the Divinity with a nearer view of himself, sends forth from its retirement some bold thought, some quiet reclamation on behalf of common sense, or some sincere appeal to the general reason of mankind, at which the surly logicians, amid all their security, cannot help being angry and amazed, and in presence of whose silent majesty—albeit in the mere commencements of its power—their cumbrous and imposing superstitions tremble in ominous presentiment of their fate. Even at such a moment—the moment of the seeming triumph of the Ptolemaic machinery—in the hour of its glory and pride—this still small voice was heard, issuing from the solitude of an unknown Polish ecclesiastic, promising to lighten us on the true way towards celestial truths, to open prospects of the Heavens new, vast, and inappreciable, and to reveal a more exalted knowledge concerning the power and wisdom of God! The promise was bold, but to the very letter has it been kept. By the word of this Pole, the curtain of the outward senses was rolled up, and the Universe exhibited in its own majestic attributes.

The obscurity of the times in which he lived rests over the early character of Copernicus. We do not know how far favorable circumstances contributed to the development of his genius, or whether, without peculiar advantages, he owes all to an inborn energy. But whatever his mental culture, the greatness of his mind he could borrow from no one, as of all who had yet lived, he was the first to accomplish a task most difficult for man. Feeling, with the intuitive force of the highest genius, that those popular systems of the Heavens could not be true, and at the same time recognizing that the logic which sustained them was impregnable, he threw from him the weight of the belief of ages, and quietly asked whether that fundamental tenet, which asserts that the Earth is motionless, might not be false.* The mental effort required, even to hesitate on a point which all mankind had up to that moment undoubtingly believed, and which had now inwoven itself with all their modes of thought, was an achievement for the highest order of genius; the question being put, it required only superior but not uncommon talent, to follow it to its conclusions. . . Modesty—a characteristic of the finest minds—induced Copernicus, after he had obtained sight of this great idea, to search through the ancient philosophies, lest perchance there might be precious relics buried there, which could confirm and encourage him; and accordingly he did find certain hints, touching apparently on a simple order of things—hints which his correct and discriminating intellect speedily methodized into that system which, in the somewhat hyperbolical language of his successor Tycho, "moved the Earth from its foundations, stopped the revolution of the firmament, made the sun stand still, and subverted the whole ancient order of the Universe."

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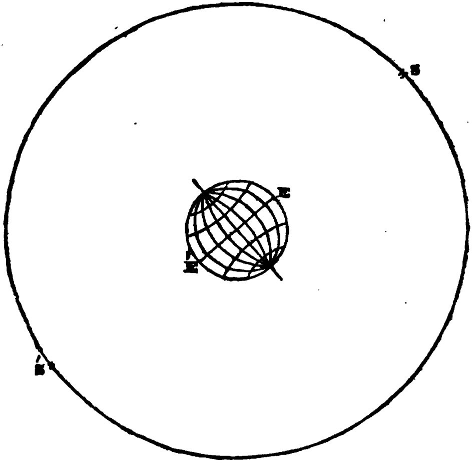
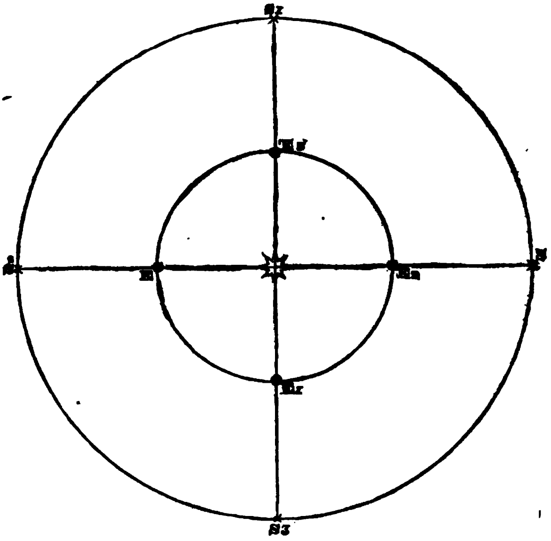
* I have seen it stated that Copernicus was a great man by accident,—that he owes his name to a happy conjecture! Let the authors of this opinion review the whole history of mankind, and reckon the number of such happy conjectures!

Having obtained and been confirmed in distinct possession of the idea, that *the apparent motion or change of place of an external body may be owing either in whole or in part, to the motion of the spectator*—as, for instance, the seeming motion of objects passed by one riding rapidly—Copernicus proceeded forthwith to inquire systematically how far the apparent motions of the celestial bodies might be produced or affected by actual motions on our parts, and the following were the results.

In the first place, the grand apparent diurnal revolution of the fixed stars easily resolves itself into a real diurnal rotation of the terrestial globe upon its axis. For instance, a spectator on the Earth at E would at that moment see the star S at its highest point, or at the middle of its course; and after the globe had made half a revolution on its axis from west to east, so that the spectator should have reached the position E′, the star S′ would appear at the highest part of its course, and S would have long set. During the passing of the spectator from E to E′, all the stars between S and S′ would have appeared to rise successively to the highest point of their paths, and then to decline and sink below the horizon; so that the heavens would have seemed in that time to make precisely half a revolution from east to west, although the spectator had merely been himself in motion,—being carried along by the noiseless rotation of the earth. The simplicity of this explanation at once assured Copernicus it was the true one; and thus his earliest achievement restored these remote and glorious bodies to their natural profound repose, and dashed from the heavens that grand crystal sphere—the origin of all subsequent delusions—the sphere which the feeble wits of men had imagined to guide and contain the stars.

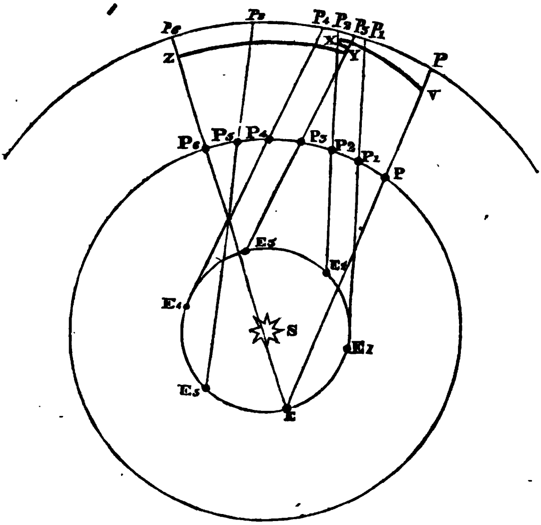


But if the Earth, a comparatively small globe, revolves on its axis, may it not also, as well as Mercury, Venus, Mars, &c., have a motion through space—may it not, in fact, be likewise a planet or wandering star akin to these other orbs, and related with them to the Sun—the general source of light and heat—as to a common centre? The apparent motion of the Sun around the Earth presented no difficulty to this explanation, for, as will be seen by aid of the subjoined diagram, the supposed orbital motion of the Earth would produce the same phenomena. Let the Sun occupy a central position, around which the Earth E revolves annually in an orbit. When the Earth is at E, the Sun will manifestly be projected on the point S of the sphere of the fixed stars, that is, he will appear to the Earth's inhabitants among the group of stars at S. When the Earth is at E′, in the same manner the Sun will appear at S′, in other words, during the revolution of the Earth in its orbit from E to E′, that luminary will have appeared to revolve through the heavens from S to S′; and pursuing the illustration throughout, it may be seen that the annual motion of the Earth around the Sun would just cause an apparent annual motion of the Sun around the



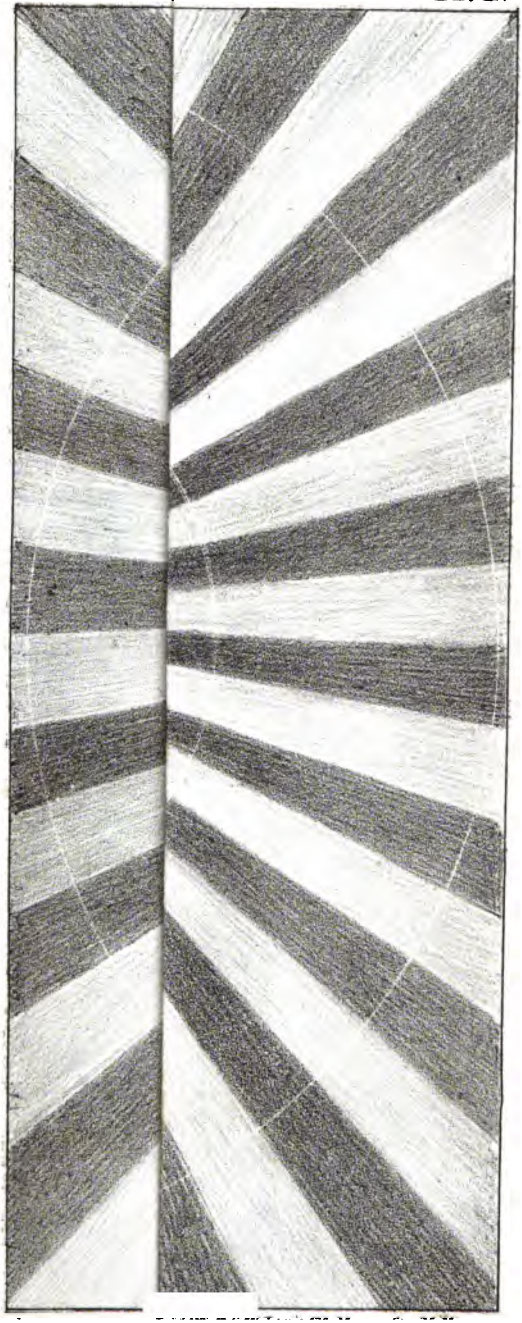
Earth. In so far as this goes, no objection could be started to the Copernican hypothesis—nay, inasmuch as the Sun is a body of immense dimensions compared with the Earth, and has, as the grand dispenser of light and heat, most intimate relations with the whole system, it seemed more than probable that the new theory was the real one; but another step immediately taken by our astronomer, conferred upon his conjecture every attainable stamp of demonstration. He lost no time in devoting attention, to those puzzling phenomena—the retrogradations of the planets—which had called so many crystalline spheres into existence; and, under the light of the new system, even these vanished into the most perfect regularity. They arise, as he found, from the different or relative velocities of the Earth and the other planets, and from the fact that *we, in motion, observe bodies also in motion.* The effects of this may be represented with the utmost plainness.

Suppose as before, that S, the Sun, is in the centre of the Earth's orbit, E E_1 E_2, &c. and that the orbit of a superior planet, or of one more distant than the Earth, is P P1 P_2 P_3 &c., &c. When the Earth is at E, if the remoter planet is at P, its place among the Fixed Stars will manifestly be at *p*. Let the Earth and the planet both move, one to E1, and the other to P^1, the place of the planet will then seem at p_4. After another interval, during which the earth and planet have moved to E^2 and P^2, the planet's apparent place will seem at p^2; and since the beginning of the epoch we have supposed, it will have had a *direct* motion among the stars, *i. e.* in the same direction as the earth. But when the Earth moves from E_2 to E3 the order of apparent motion wholly changes, for the planet actually at P^3, will now seem at *p*3 among the Fixed Stars, or to have *retrograded* from *p*2. After another mutual change of place, its motion, as shown by the diagram, again appears *direct ;* and if the illustration be pursued through the whole course of the Earth's motion in its orbit, it will appear, that during that course, the planet, without departing from its own regular path, will necessarily seem to terrestial observers to describe the old, irregular, and twisted V X Y Z, to which the artifice of small circles, moving on the circumferences of others, owed its origin and plausibility. Thoroughly imbued with the spirit of a strict geometer, Copernicus was not satisfied with the general light which thus broke upon him. This idea was evidently fitted to show how irregularities and retrogradations might take place; but the question was whether the *observed irregularities and retrogradations were consistent with it ?* Accordingly, using the best means within his reach, he constructed a theory of



the apparent motions of every planet; and the results corresponded so closely with observation, and offered so thorough an explanation of all the phenomena represented in Plate I. that nothing was left to his opponents, but the interposition of metaphysical arguments. And potent these soon became! Not potent in themselves, but from the multitudes who uttered them! The utterance of the merest imbecile, may, if sufficiently echoed and repeated, amount to a noise adequate to stun the whole earth; and surely, the circles and spheres of Ptolemy, now so dear to the Ptolemaic *sect*, could never fall unaided, or go to their graves without adequate death-dirge! The intellectual world approached a volcanic epoch.

It can scarce be necessary to point out in detail the superior simplicity and grandeur of the system of the universe brought before men by the Polish philosopher; language indeed can hardly express one's impression of its contrast with that narrow unravellable confusion which the Ptolemaic had become. I have already stated, that the notions of Purbach are, as a whole, utterly unrepresentable; but on the contrary, Plate IV. will give an adequate idea of the simplicity and harmony now unfolded. Five planets have been discovered since that time, and many moons or satellites, but no exception has been ever found to the law, that the planets, including the Earth, move in steadfast orbits around their great light-giver, and that the satellites, like our moon, roll around the planets they attend. Beautiful though the scheme thus appears, it is, however, in referring to its revelations concerning the Fixed Stars, that we can best ascertain its vast moral effects. What a change must come over the mind, when from the idea that this Earth is the centre around which all things are symmetrically arranged—the body for whose



UNIV

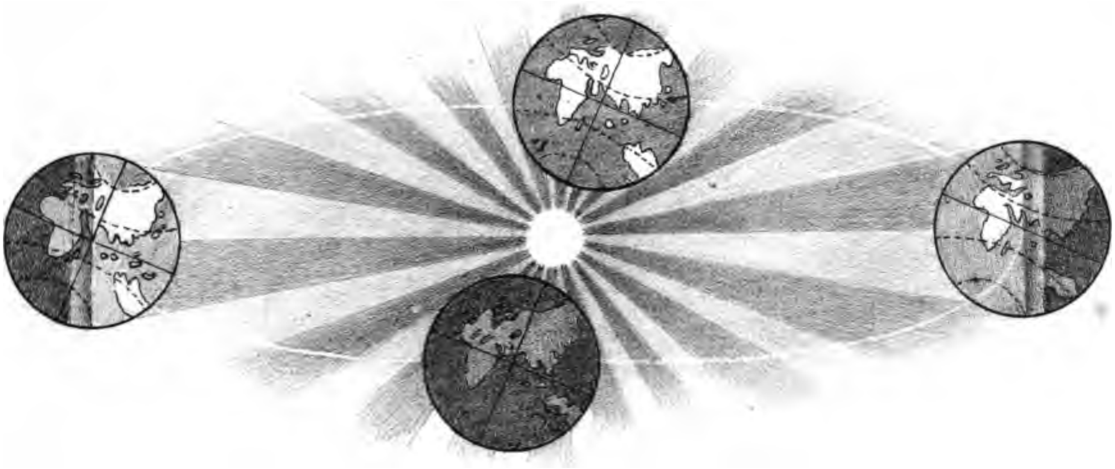
sake the brilliant fret-work of the skies was hung up—we pass to the conception that it is merely one of a small class of orbs attached to the Sun, and by no means the largest of these ; and that those multitudes of Stars, greater than the eye can number, or even the imagination conceive, are globes like the Sun, only lessened by their immeasurable distances, but around which planets may also roll, and all space be thus filled with motion and life ! Doubtless there is here wherewith to stun the self-important, and startle the timid ; and it is not astonishing that demurs arose among believers in the narrow creeds of those days ; but indeed, that mind only can be afraid to look at the Universe as it typifies the greatness of its Creator, which knows not the comprehensiveness of the glance of an Almighty eye. The love which warms the blue depths of space, holds within it also our microscopic earth, which even in its most microscopic atoms, teems with fine arrangements, so minute and manifold, that man is yet baffled in his ambition to know them all, where the smallest creature that creeps along the ground, has its home, its roof-tree, and its young, its passions, affections, and loves, —where one drop of water swarms with myriads of living beings, each drinking up life and happiness within the sphere of laws that know no caprice, and is exquisitely adapted to its place ! Yes ! O reverent adorer, the God of these shining skies, is also the Being who provides the young ravens with their food ! . . But even the interest of these general views does not incline us to overlook the fine harmony as to minor arrangements which now appeared in the scheme of the Heavens. The two simple motions of the Earth produce our day and year. Revolving on its axis in 24 hours, the Earth turns every part of its surface in that period towards the Sun ; whence a regular succession of light and darkness : and to a peculiarity connected with its yearly orbitual motion we owe the change of seasons. The source of this most pleasing variety, is in the *inclination of the axis around which the Earth daily rotates to the path or orbit through which it moves annually.* This is a point which can be illustrated with most effect pictorially, and in Plate V. all its aspects are presented. The inclination of the axis, to the orbit, causes, as will easily be seen, the Sun's rays to fall more or less *directly* on the same part of the Earth, in different parts of its orbit, and hence, as before explained, the variety of their heating effects. How exquisite the adjustment of our world to such variety! Think of the action of winter as a season of sleep and refreshment to vegetation,—the bursting of its dormant powers in spring,—its manhood and health in summer,—and in gentle autumn, the time of the sere and yellow leaf! Though observation informs us that there are Spheres in which little of this change is seen, and where doubtless, all arrangements are equally beautiful; we may be pardoned for contemplating with especial interest so much of the course of our own world, and permit our sympathies to flow freely with the poet, who thus opens his fervent, but somewhat pantheistic hymn.

> "These as they change, Almighty Father,
> These are but the varied God!"

On matters of this kind, men feel variously; I confess that to me the sight of such exquisite adaptation—an adaptation of phenomena mighty and minute, affecting as the seasons do, although mysteriously, not only the death, but the birth of human and all animated beings—it does appear that such precision of workmanship and steadfast solemnity of march, are as strong and eloquent proofs of the presence of the Godhead, as those deviations from or-

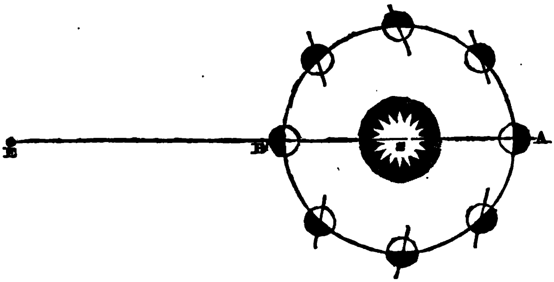
THE SEASONS.

Pl. V.



dinary agencies, which, in the course of providence, the Almighty has thought fit to produce; and that with a far loftier and more intelligent ardor than that of the Egyptian magician, we may exclaim, as we humbly contemplate, The finger of God is there.

The Copernican theory was not—with all its simplicity—free at first from real difficulties. The imperfect condition of mechanical science exposed it to objections of much plausibility and strength; and there was one other so very peculiar, that I cannot pass it without especial notice. If your scheme is correct, said the opponents of Copernicus, *Venus* should have phases like the Moon. The truth asserted was geometrically sound. Supposing S the Sun, E the position of the Earth, and the circle around the Sun the orbit of Venus; it is plain that inasmuch as the enlightened half of Venus, or that half turned towards the Sun, is not at the same time (except in one single position) turned towards the Earth, the full disc will never be seen except when the planet is at A; and that in all other positions, she must like the Moon appear incomplete and *horned*. Nothing of this, however, is visible to the naked eye; Venus always appears a brilliant evening or morning star, and her shape is lost in the



brightness of her rays. The difficulty, therefore, was a critical one; and the mode in which Copernicus dealt with it, is another and most emphatic proof of the greatness of his mind. An inferior person would at once have "denied the fact," and brought forward metaphysical reasons of a kind then much in vogue, why Venus should not be subject to such laws; but after some wavering, our astronomer boldly acknowledged the accuracy of the deduction, and in the finest spirit of prophecy, added without hesitation, that should men ever see Venus better they would discern her phases! And singularly enough, the verification of this confident prediction was one of the earliest achievements of the telescope. . . Dealing with the same discrimination with alledged faults arising from inconsistencies between the new system and those vague and indefinite conceptions of which man's knowledge is always more than half composed; the discoverer clung unshrinkingly by the grand truth which had been revealed to him, and trusted the clearing away of difficulties to a more instructed posterity. Affected, however, by a modesty which had a parallel in after times in the conduct of Newton; he was long in giving his authenticated labors to the world, and the proof copy of his work on the REVOLUTION OF THE CELESTIAL ORBS, reached him only on his deathbed, when, in the words of his admirable friend the Bishop of Culm, he was occupied with weightier cares. There is something strangely solemn in that concurrence—the mortal was expiring and about to crumble into dust, and at the same moment his name was being clothed with majesty and honor—going forth in glory and power, to live at least as long as this world! The frame which contained Copernicus partook of the fates of that of other men, and was laid down to repose within the precincts of the mountain church of Frauenburg. Rude spheres engraven on his tomb, and a half effaced name still mark the sacred spot, which was lately sought out and identified by two pious Poles: at whose instance a statue was erected and consecrated to his memory, and crowned before a mighty and reverent assemblage in the great square of Warsaw, in that recent year in which Poland ceased to be a nation.

We learn from tradition that Copernicus was a man of fresh complexion and fair hair,—so grave that at first sight one might have deemed him austere; but such impressions were momentary. Mild and gentle, unostentatiously benevolent—he was one to reverence. His demeanor was even, steadfast, and still; he cared not for jests or irrelevant reading; and he never broke a friendship. Foreordained to a great work, his mind kept itself near the fountain of truth, by nourishing all the affections.

§ 2. *Galileo.*

The history of the establishment of the true theory of the heavens, leads us now to other climes—from the damp borders of the Vistula to Italy's fairest region, where we light upon a mind united to that of the illustrious Pole by the closest sympathies—not merely by unity of opinion, but by the eminent possession of a power to supply precisely what Copernicus knew not—I mean the Florentine Galileo. This is not the place fully to do justice to Galileo, for his labors stretch far and belong to many sciences; and even with regard to his services to Astronomy, we must be satisfied with the briefest sketch. The question of the invention of the telescope is not in my estimation, one of difficulty or doubt. A combination of glasses, producing a magnifying effect on remote objects, was hit on by the merest accident by a Dutch spectacle-maker, and Galileo hearing of the accident, but without knowing the combination which produced it, directed his mind to the point, and produced an instrument, which, in his hands, immediately yielded results worthy of so great a discovery.

As the physical character of the celestial bodies will receive full discussion in an after part of this work, I shall not advert here to any discoveries by Galileo, which had not direct influence upon the debate stirred by Copernicus, and which was now beginning, after the death of its author, to agitate all the schools; neither will my limits permit more than a passing reference to the fresh and beautiful style in which those discoveries were announced—a style so fresh that when one reads it, facts which have been long familiar, put on once more all the charms of novelty and youth. It will be seen, however, from the following short sketch, how very important to the elucidation of the Copernican theory were the labors of the great Florentine.

1. One of the first fruits of telescopic observation was, as I have already intimated, the discovery of *the phases of Venus.* This beautiful planet was no longer a stumbling-block, but a grand and capital confirmation of the central position of the Sun; and the discovery must have produced the greater effect with candid minds, because of the fact, that the supposed non-existence of the phenomenon now verified, was adduced as an argument against the true doctrine. One cannot avoid regretting that Copernicus did not live to enjoy this signal triumph.

2. Galileo next discovered the *rotation of the Sun upon his axis.* This mighty globe revolves around his axis in twenty-five and a half days, as Galileo discerned in the

motion of those singular *spots* upon the surface of the Sun, whose nature was explained only in our times. Now one of the grand objections of the Ptolemaists to the rotation of the Earth, and the consequent removal of their favorite crystalline sphere, was this, "How is it possible that the Earth can move—a ponderous mighty body! Motion is quite unnatural to such a mass, whose proper disposition is sluggishness and repose." Observe how the discovery of solar rotation bore upon these fine metaphysics! To reply by reasoning was out of the question, because impossible; but here the metaphysicians encountered a FACT. *The Sun, a far mightier and nobler orb than the Earth, rotates on his axis,—therefore why may not the Earth rotate?* . . Without reference to this argument, the fact now brought to light was a first step towards the establishment of a great cosmical phenomenon.

3. The Earth, said the Ptolemaists, is far more dignified than the other planets, which we allow to have orbitual motions. It is, as you Copernicans confess, attended by the Moon; and none of the other planets have such attendants. But the proper position for a dignified body is repose, and, therefore, the Earth must be at rest! O LOGIC! what a shock you had again to encounter! The wonder-revealing tube of Galileo, directed to the planet Jupiter, discerned that this magnificent body—the grandest in our system—is attended by the imposing cortege of no less than *four Moons*, constantly circling around him: but, Jupiter, as the Ptolemaists agreed, had a motion in an orbit; and yet, tested by their own principle, he is four times more dignified than the Earth! Quitting for a moment the scene of dispute, I may be pardoned for referring to the intrinsic interest of this splendid discovery. Not only did it exhibit the Solar System in beautiful epitome, for such is that scheme of orbitual movements of which

Jupiter is the manifest centre; but it suggested the idea, that our System itself is not the last nor the highest of such mechanisms,—that even as Jupiter with his train revolves around the Sun, that luminary himself with his attendants primary and secondary, may also sweep around some other centre,—nay, that the countless hosts of heaven may be bound together by similar sympathies, and co-operate in the production of cycles almost adequate to represent eternities!

Were man exclusively a truth-seeker, how happy had been inquirers at the occurrence of so great and wonderful a source of knowledge—how welcome these revelations of the telescope! But, instead, they were the signal for all discord and passion: they began the fierce war between the old and new Opinions. Galileo and his telescope were hated—and with most perfect sincerity; his opponents would not even look through that glass; and I believe, the mere sight of it, had as terrifying an influence over learned Academicians, as the musket of Cortes over the Mexicans! The senses having unexpectedly turned crown-evidence, the learned divan of Europe flew back most resolutely on metaphysics, and would have nothing whatever to do with the evidence of the senses. The discovery of the Satellites especially—the four new planets as they were then called—instead of being welcomed as throwing new light on the wonders and order of the Universe, was a heresy which ought above all things to be put down. Francesco Sizzi, an astronomer of no mean note, and a townsman of Galileo's, thus gravely and impressively delivered himself:—" There are seven windows given to animals in the domicile of the head, through which the air is admitted to the tabernacle of the body, to enlighten, to warm, and nourish it; which windows are the principal parts of the microcosm or little world, two nostrils, two eyes, two ears, and one mouth,—so in the heavens, as in a macrocosm or great world, there are two favorable stars (Jupiter and Venus), two unpropitious (Mars and Saturn), two luminaries (the Sun and Moon), and Mercury alone undecided and indifferent. From which and many other phenomena of Nature, such as the seven metals, &c., which it were tedious to enumerate, we gather that the number of planets is necessarily seven. Moreover, the Satellites are invisible to the naked eye, and therefore can exercise no influence over the Earth, and therefore would be useless, and therefore do not exist. Besides, as well the Jews and other ancient nations as modern Europeans have adopted the division of the week into seven days, and have named them from the seven planets; now, if we increase the number of planets, this whole system falls to the ground! ! ![*]

Reader! in judging of Sizzi's logic, beware of *one* inference,—Sizzi was as sane as yourself!

There is much emphasis in that last paragraph;—"If the new planets were acknowledged, what a chaos would ensue!" Repose-loving man cares not to be disturbed by discoveries,—he prefers old opinions, somehow as Selden liked his old slippers—because they were easiest for his feet.

The *spirit* as distinguished from the mere *opinions* of these times, will be tolerably apprehended by an expression of another astronomer,—a young German, Martin Horky. "I will never," says he, "concede his four new planets to that Italian, though I die for it." Horky was very valorous, but the suspicion is, he would rather have made Galileo die for it.* Nothing of this uproar disturbed the calm and even soul of the great Florentine, or bent him from the way of truth; and he simply replied to the vagaries of the thousand Sizzis, "That although these arguments might have force in inducing us to believe beforehand, that no more than seven planets existed; they were hardly sufficient to annihilate those new ones which were actually seen to exist." The following is a letter written by him at that time, to a man after truth's own heart,—John Kepler:—"Oh my beloved Kepler, how I wish that we could have one laugh together! Here at Padua is the principal professor of philosophy, whom I have repeatedly and urgently requested to look at the Moon and planets through my telescope, which he pertinaciously refuses to do! Why, my dear Kepler, are you not here? What shouts of laughter we should have at all this solemn folly! And figure the Professor of Pisa laboring before the Grand Duke with logical arguments, as if with magical incantations, to charm the new planets out of the sky."† Galileo could well afford to laugh, for he knew that the telescope would become a common instrument, and that, on behalf of all his discoveries, the universal sense of mankind would soon be with him. Of course it has been so. Looking backwards to that time, the eye discerns much cloud and dust,—the school-boy world sulking and noisily refusing to be taught. One figure alone is clear, standing indestructible, with his far-reaching tube—in a niche in the temple of Truth!

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[*] Quoted from Mr. Drinkwater's excellent Life of Galileo.

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* There is a whimsical incident connected with Horky. He had been introduced to Galileo by Kepler; and like other creepers, imagined that abuse of Galileo would please his patron. Finding himself grossly mistaken, he sought to be reconciled to Kepler to receive pardon. Kepler writes, that he had pardoned him, but not until he had compelled him to look through a telescope, and to confess that he saw Jupiter's satellites! The penance was indeed severe!

† Circumstances compel me to rely for this letter on my memory. I am certain, however, that it is almost *literally* accurate.

It was evident from the first, what would befal Galileo. He was too near the centre of the power wielded by these metaphysico-theologians, to escape; and in those days there were no counterbalancing powers.

In the first place, the idea of the motion of the Earth was declared *heretical* at a formal and solemn meeting of the Sacred College: and Galileo, its most celebrated defender, was cited before the reverend tribunal, and asked to retract his theory. Firm and moderate although he was, the instincts of humanity at first prevailed, and he entered into an agreement, not again to demonstrate that the Earth moved. I verily believe, that the venerable astronomer—for then his head was blanched, not by grief or care, but by effect of delightful watchings—I verily believe, that, trusting to the ultimate consequences of what he had already done, and doubtful of the issue of truth, he meant to fulfil his promise! But as well might the old man have aimed to rule the whirlwind or chain the thunderbolt! The feeling of Truth,—the feeling that he was possessed of great discoveries, would have burst all the bonds within which he could possibly have compressed himself;—Nature does not give a man a great secret that he may repose with it. Love of the Heavens accordingly prevailed, and again Galileo taught the grandeur of God's Universe. A second prosecution awaited him; when, once more bending to the weakness of the flesh, he signed the following abjuration: "I, Galileo, in the seventieth year of my age, being brought personally to justice, being on my knees, and having before my eyes the Holy Evangelists, which I touch with my own hands, with a sincere heart and faith, I abjure, curse, and detest the error and heresy of the motion of the Earth." . . . What a spectacle! A venerable old man—worthy to be the idol of his age, and who has been the worship of posterity—one whose grey hairs it might have delighted every lover of truth to touch in reverence—compelled to self-desecration, by that unholiest passion in man's bosom—his anger that others do not think like himself!

At the age of seventy, blind old Galileo was placed under restraint, because he had unravelled to man the beauty and simplicity of the order of the celestial spheres. No longer, then, could he trace and mark the motions of those pure orbs, but in thought they were the same to him still; and perchance that short period of sorrow, called into more vivid action those energies and ethereal imaginings which are most suitable for a less troubled sphere.

During the confinement of Galileo, he had one visitor, whose fame is as enduring as his own. While on his travels through Italy, our Milton, under all risk of obloquy, sought out his residence, and held converse with the astronomer. It is clear they had talked of all things but misfortune; nor could Milton have wished otherwise, than that if ever his fates were untoward he might be like Galileo. And the wish had been prophetic! The days came when all around the illustrious bard—both moral and physical worlds—were dark, dark as the extinguished orb of noon! In that moral midnight, when birds of evil were screaming and screeching around him his heroic soul remembered of Galileo. The Florentine cheered his gloomy term, by visions of the bright stars, and the immortal poet by dwelling on those principles of justice, of beauty, and love, which guide the moral providence of the Almighty.

The ashes of these illustrious men are divided—one reposing in a chancel in Old Florence, and the other within a British fane, but their Spirits are one ; and that not alone by union in yon after World, where all that is Good and Great will eventually commune, for even here a harmonious influence arises from their dust—an influence to give firmness to the timid, constancy to the wavering, and to such as deserve well of mankind, the assurance of a prolonged and honored existence.

CHAPTER III.

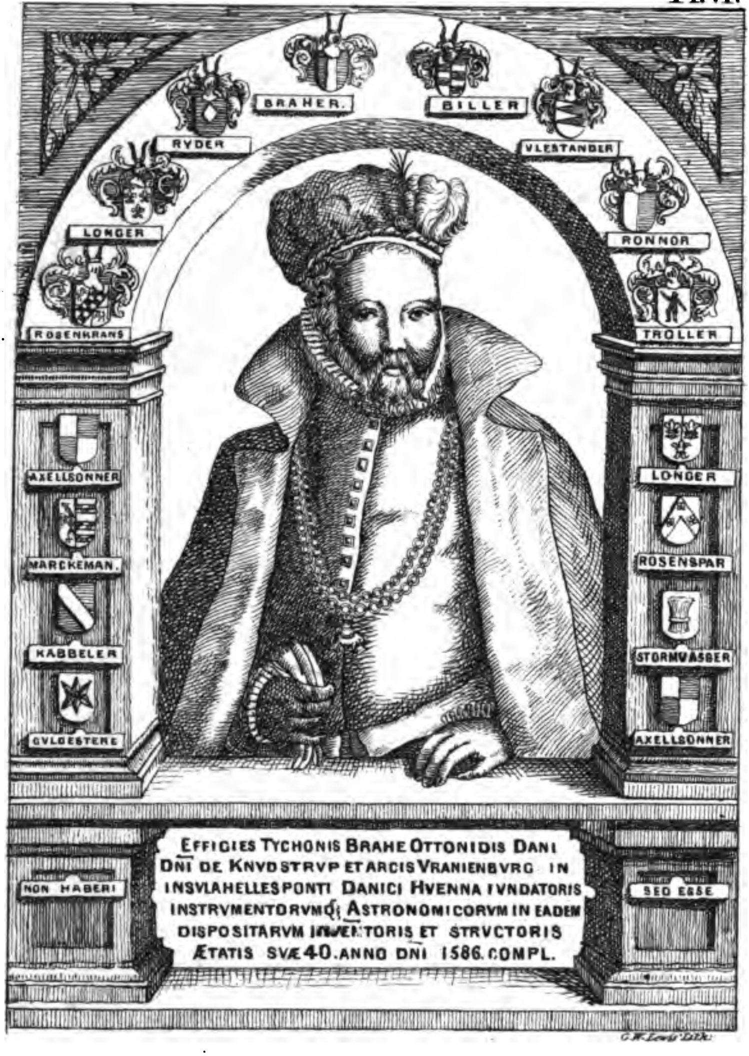
THE ADVANCE OF OBSERVATION

The course of history leads us again to the remote north. Ranging over Europe to discern what is being accomplished for knowledge, the eye is arrested by a singular and gorgeous structure, in the midst of a small and desolate island in the Baltic Sea,—a citadel which must be the abode of a Noble, for the archways of its gates are surmounted by numerous escutcheons; but, mingled with these, strange cabalistic devices might be seen—figures of machinery, of no application to the usual actions of those troubled times; and within, for the most part, there is silence and watching, neither the voice of constant orgies, nor the clash of arms. In Europe this structure stands alone, dissimilar to every existing castle, obviously performing some most peculiar function; and the story which appertains to it and its remarkable Inmate has almost the air of romance.

By the labors of Copernicus and Galileo, the first fundamental tenet of the ancient astronomy was destroyed, and the character of the earth established; but, so far from foreclosing further progress, the new theory had not touched on that second dogma, which related to the kind of curves or paths in which the planets move: nor indeed was the elucidation of this point yet possible; inasmuch as the imperfect means hitherto at the command of inquirers, were quite inadequate to detect those subtle variations by which the revolution of each body might be distinguished, and from which alone the nature of its course could be evolved. Astronomy therefore called urgently for a man to gather in fresh treasures by observation, to accumulate materials for future architects: and He who was thus summoned appeared straightway upon the scene—the man to whom the puzzling edifice referred to belonged.

Tycho Brahe, the Dane, was born in the year 1546, the son of noble parents. Intended by his relatives for a jurist—a lucrative and courtier profession, he was desired to peruse the codes of law, and to plunge among all old commentators; but genius acting within him, as it ever does when real, as a passionate instinct, aided by an unusual portion of that resolute self-will which in those ages often came by noble blood, turned Tycho from commentators with irreconcileable disgust, and forced him on his destiny. In vain did threats of disinheritance and even exile, menace the close and ardent student of the Heavens; the bright book there, was the book he was born to read, and not ponderous pandects. The persecutions of kinsmen, however, in connection with difficulties flowing out of a midnight duel with another young Danish nobleman, were on the point of causing him to abandon his country for ever, when accident engaged in his behalf the pride of his sovereign. Casual correspondence with the Landgrave of Hesse—himself an estimable astronomer—made known to the King of Denmark the value of Tycho; when feeling immediately the loss threatened by the

Pl. VI.

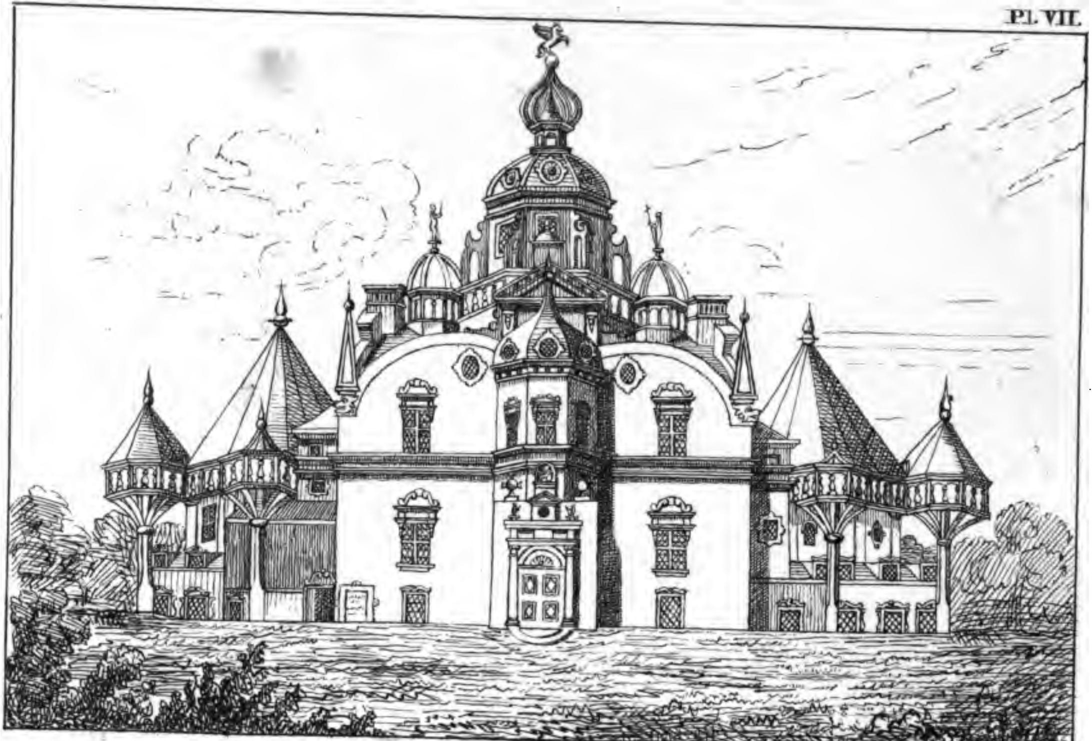

BRAHER.
BILLER
RYDER
VLESTANDER
LONGER
RONNOR
ROSENKRANS
TROLLER
AXELLSONNER
LONGER
MARCKEMAN.
ROSENSPAR
KABBELER
STORMVASSER
GVLDESTERE
AXELLSONNER
EFFIGIES TYCHONIS BRAHE OTTONIDIS DANI
DNI DE KNVDSTRVP ET ARCIS VRANIENBVRG IN
INSVLA HELLESPONTI DANICI HVENNA FVNDATORIS
INSTRVMENTORVMQ; ASTRONOMICORVM IN EADEM
DISPOSITARVM INVENTORIS ET STRVCTORIS
ÆTATIS SVÆ 40. ANNO DNI 1586. COMPL.
NON HABERI
SED ESSE

C.W. Lewis Lith.

withdrawal of the astronomer, and also perhaps instigated imperceptibly by that reverence for knowledge which was beginning to have a place in Europe among the moving causes of men's actions, his Majesty, with a munificence which Denmark's kings have in most part inherited, offered Tycho a boon too welcome and suitable to be refused—the property of the island of Huen—a small spot between Sweden and Zealand, and the promise to build and endow him an observatory to his taste. This was the turning point of Tycho's life; and from this moment behold the descendant of a long line of ancestry, gladly enclosed within the circuit of his little island, far from war, from courts, from martial honor, but gaining for himself a nobility whose claims and station will never wane or sink under any of the revolutions of time. Not, however, that Tycho was indifferent to the honors of chivalry. The idea that in the Astronomer, he forgot or overlooked and laid aside the Baron, would give the falsest impression of him. Astronomer, the greatest in his line that Europe had yet seen—he was still in all things the Feudal Chief; and the despotic will of the Noble, probably added to the energy and clear determination as well as to the somewhat haughty roughness with which he accomplished his task. Inquire of himself. Plate VI. is his effigies, shaped out by his own care, and which I gladly reproduce;—in every inch the NOBLE DANE! Reckon up these armorial decorations—the shields of all his relatives, paternal and maternal; but do not overlook the motto! NON HABERI SED ESSE. NOT TO BE ESTEEMED MERELY, BUT TO BE WORTHY OF ESTEEM. To be a *man*, not a *counterfeit;* to be worthy if possible, but at all hazards to be and appear what he was; to be, I repeat, a MAN: and such he was; one with many weaknesses and some rough vice, but than whom this world has seen few better and none greater since the Earth received him back into her bosom.

Turning from Tycho to his citadel, what wonder now that its aspect puzzled us? Apart, indeed, were the objects of Uranibueg, *i. e.* the Castle of the Heavens, from what might have been the possession of Tycho, or that in which any other Noble ever lived. Its dimensions, however, were princely. A wall twenty-two feet high enclosed a square whose side was three hundred feet; and in the middle of each side were large gateways, with ample residences for retainers. In the centre of this square stood the Castle, of which Plate VII. is the elevation, as drawn by Tycho. The length of its chief front was sixty feet, the diameter of its circular wings twenty-two, and its altitude from the doorway to the Pegasus on its highest dome seventy-five. For the family within it, it contained ample accommodation, viz. for Tycho and his wife (a woman of low degree, whom not wisely, he married that she might rather be as an handmaiden); his children of whom nothing ever came; and his corps of assistants whose personal history is in some cases as odd as his own. There were halls, too, for the hospitable regaling of strangers; and on demand Tycho could wassail with the best of them, as we learn from hints concerning certain profound potations:—but the rightful and chief occupants of Uraniburg were those magnificent instruments, invented for the most part and constructed under the immediate eye of our astronomer, by which quantities could be measured more minute than it had heretofore been considered of consequence to note, and advances thereby made towards our acquaintance with the finer mechanisms of the Universe. That fine and beautiful machinery was the first product of the genius of Tycho. Besides

Pl. VII.

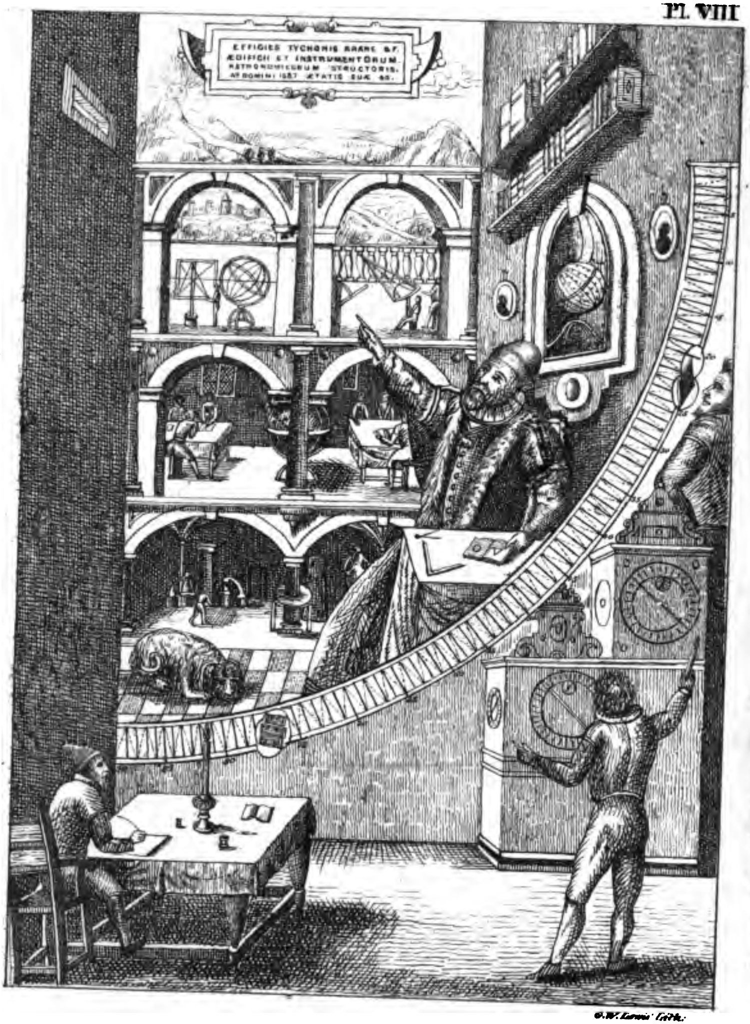


G. W. Lewis' Lith.

URANIBURG.

UNIV. OF MICH.

Pl. VIII


EFFIGIES TYCHONIS BRAHE O.F.
ÆDIFICII ET INSTRUMENTORUM
ASTRONOMICORUM STRUCTORIS.
Aº DOMINI 1587 ÆTATIS SUÆ 40.

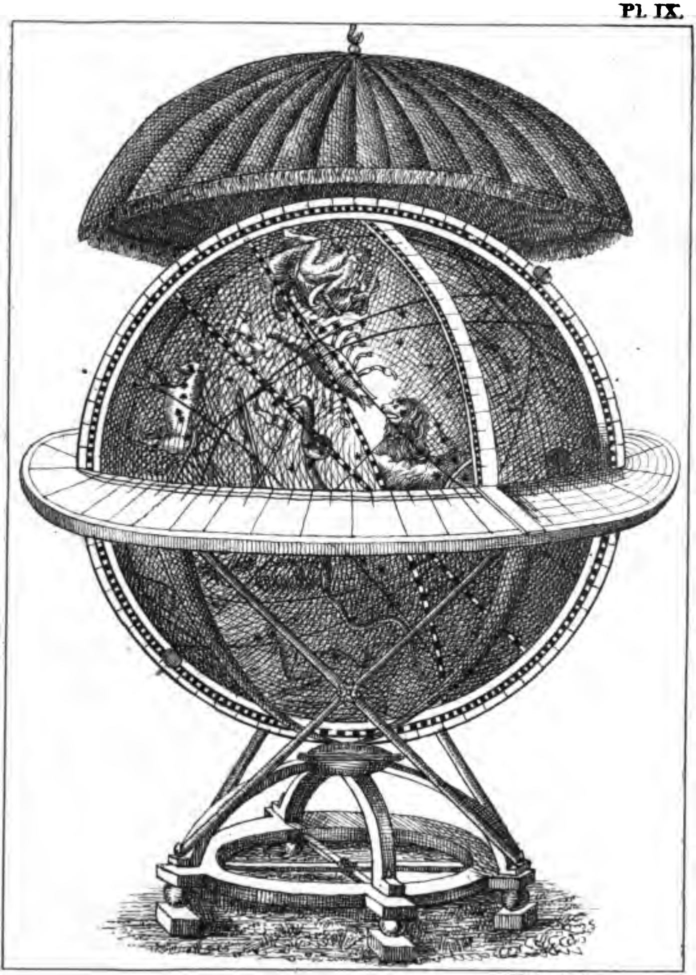
G.W. Lewis' Lith.

UNIV. OF MICH.

what he obtained from his king, he expended on it the greater part of his private fortune, and had thus a double claim to honor in his success. The instruments of Hipparchus with little modification, had, until then, been the only instruments of much use in astronomy; but those called into being by Tycho were as far superior, as the exquisite productions of modern art surpass the fabrics in Uraniburg. Attached is his own view of the interior of his citadel (see Plate VIII.) not even unaccompanied by his favorite poodle, by which, as we shall see in the sequel, an important issue hangs! ! ! Well and sedulously were these instruments used—amply did they fulfil the desire of their framer and ruler in subserving his grand ambition. I characterize that ambition as highly as language will permit, for no praise can be too great for the perseverance and genius of the Man stationed upon this earth, separated from these bodies by intervals so mighty —who formed the plan, and thoroughly succeeded in noticing their most evanescent mutations—events so remote, so variable, and transitory! In my mind it adds to the merit of Tycho that the changes observed, were to him simple and *unintelligible* facts. He had no theory to support by his observations, for they often went against all received theory; and were not wholly understood until long after, when the universal law was given. Tycho was borne through his task by the solemn conviction, that although he understood them not, he was delivering important tidings, and that their interpreter would come. . . I know that such labor of mere observation appears to many a low and common-place labor, not requiring intellect; but they are subject to the grossest misapprehension. The fact is, that the union of qualities essential to a great observer is most rare. Not only does it require a delicacy of what I may term mechanical *tact*—a fineness of perception while touching and turning an instrument of which few men are possessed,—for it must be remembered that in astronomical observations, a single hairbreadth is often the quantity on which the resolution of a problem turns; but it needs a power to distinguish, as if by intuition, the essential from the non-essential—to light at once upon the important feature of an evanescent phenomenon, and to seize and appreciate it, which is among the higher attributes of thought; and then how even the perseverance, how stern the constancy, how unceasing the watchfulness of the man who not only separated from them by distances all but appalling, but debarred often from their sight by impenetrable clouds, shall yet devote his life to the pursuit of these wandering bodies through their intricate mazes! Now every one of these faculties appears to have been bestowed in prime perfection on the Noble Dane; and never did human being more sedulously and worthily employ the talent entrusted him by his Creator. There was never slumbering with Tycho. His [illegible] when even cursorily glanced over, strike the peruser with amazement; and no one ever existed to whom reference might more accurately be made, in proof of what by exercise of virtue, and patience, and industry may be accomplished even during the brief lifetime of man.

From the nature of Tycho's pursuits, it is clearly impossible to detail them in a work like this with any degree of interest. *They were materials for future results;* and how ample and important they were in this respect, will appear in the next chapter. Some of the minute irregularities of the planets were noticed in his observations; and he discovered several of the most important inequalities in the Lunar Motions, the cause of which was not comprehended until Newton unfolded the true laws of the unity of things.

Pl. IX.



G. W. Lewis Lith.

GREAT GLOBE OF URANIBURG.

UNIV OF

One special and gigantic work to which Uraniburg was devoted, may, however, be briefly referred to—I mean the cataloguing of all the fixed stars. To this work, first accomplished, although in a far ruder manner, by Hipparchus, Tycho was incited by an incident, which, singularly enough, also moved the Alexandrian to undertake the same labor, viz. the sudden apparition, and subsequent disappearance after the interval of a year, of a new and brilliant fixed star in the constellation Cassiopeia. Inferring from this phenomenon, with the promptitude characteristic of a philosophic observer, that motions of vast import may proceed among the fixed stars; he resolved to fulfil his duty, by transmitting to after ages an exact representation of the state of the Heavens in his time: and, after innumerable observations, he constructed a globe upon an immense scale, on whose surface he fixed the position of a thousand stars. Plate IX. is his own representation of that globe; but, to give a true idea of it, I must specify some of its dimensions. The pedestal alone was five feet in height, and the diameter of the ball, which was covered with brass, was no less than six. This grand sphere, a type of the magnificence of all Tycho's operations, had a strange history. After the fatal dismantling of Uraniburg it was carried to Germany; and transferred, after Tycho's death, during the confusion of the Thirty Years' Religious War, from town to town, until, by a singular chance, Udalric, son of Christian of Denmark, found it in a place in Silesia, which he had just taken by siege. The prince, cherishing the fame of his country, rejoiced in the discovery, and adopted means to have the monument reconveyed to Copenhagen; where Longomontanus—Tycho's chief assistant—welcomed it with the affection of a lost and dear acquaintance, and placed an inscription on its pedestal, narrating its singular fates. I am not acquainted with its subsequent history, but would grieve if some part of it is not yet preserved in Denmark. Perhaps it was the last relic of all the instruments of Uraniburg.

Having striven to appreciate the admirable qualities of this great Observer, and to present his life as an epoch in astronomical history; I feel it incumbent to state, that to the field of observation he was limited and confined, and totally deficient in those powers which constitute the philosophic architect. Fortunate indeed it was, that he fell so aptly on the office fitted for him; fortunate that he lived when to accumulate stock was of chiefest importance; for not one stone could he himself adjust in the building of the fabric! So powerless was he, that, notwithstanding his whole observations went to sustain it, he could not see the beauty of the Copernican system; and the weight of his opposition might have seriously retarded its progress, had his successor been less enlightened and discriminating than John Kepler. Conscious that the Ptolemaic system was untenable, he attempted to rear a third, or middle system of his own, in which the stability of the Earth was preserved—a system which represented the other planets moving around the Sun, but the Sun along with them, just like Jupiter and his moons, revolving annually around the Earth. Had this system preceded the views of Copernicus, it would have been a great step in advance;—coming after them, it was an endeavor backwards. Tycho's arguments in support of his views, although indicative of a mind incapable of the largest kind of reflection, had, it must be remarked, no sympathy with the metaphysics of the Ptolemaists. His chief difficulty regarding the motion of the Earth rested on the fact, that, at opposite seasons of the year, *the stars have exactly the same apparent directions from us.* Now, said he, if, notwithstanding of our having moved through so vast a space as the length of the Earth's orbit, these bodies do still seem to occupy the same apparent places—how immeasurable must be their distances from us; and is it not utterly inconceivable, that there should be so great a void or emptiness in Nature? . . . Tycho had not surmounted the ambition to measure the Universe by the span of his own fingers: the consequences of the new doctrines stunned him by their inconsistency with his preconceived, but vague and unfounded notions, and therefore he rejected its claims.* How different the proceeding of Copernicus in reference to the difficulties concerning the phases of Venus! Evincing similar irreflection, our Observer divided his time between alchemy and his astronomical labors. Uraniburg had a suite of vaults, in which crucibles and alembics without number were in unremitting operation; and Tycho perhaps thought as complacently of his specific against epidemics (to which, as described by himself, medical men are respectfully referred) as of his observations on the planet Mars. So also was he under the bondage of Astrology, (above which Copernicus had clearly arisen), and steeped in much of the mysticism of his time.† On the confines of two ages—that of darkness and light—he belonged emphatically to both: an illustrious type of the character of our best humanity, he thirsted for new knowledge, and pressed towards it against destiny and his own defects, with the strength, but also the stumblings, of a Polypheme!

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* "What are you," Gassendi asks, "to measure the works of Omnipotence, and to compress them within the limits of your intellect? You who enjoy only a spark of reason, and creep upon a small point amidst infinity—when have you penetrated all the designs of the Supreme Creator? What certainty is there that these vast spaces, where your feeble organs perceive nothing, are really void and desolate; and although they were, do you know enough of the plans of Divinity to be assured that this immensity is not a portion of them?

† One other glance into Tycho's mind. He was a Lutheran; Denmark then belonging to the reformed kingdoms. On the verge of the Thirty Years' Religious War he could speak thus:—"Of religious controversies let Him judge absolutely, who can divide the true from the false, scrutinize all hearts, and alone decide without

I have hinted that sunshine did not last for Uraniburg. Coming as a vision, like a vision it disappeared. Tycho resided in it for twenty years: soon after its seat was an open field. *Jam seges est ubi Troja fuit.* The island was given in feoff to a noble family, name unknown;—when the inquiry was made which received the foregoing answer, Huen was possessed by a widow of that house. *O domus antiqua*, quotes Gassendi, *heu quam dispari domino dominaris!* Noble domain, indeed thou art ruled by a different master! But as is most painful to tell—Tycho was driven from it. Never did man give a more noble return to royal bounty, never has royal bounty bequeathed a more honorable or enduring memorial: Tycho, nevertheless, was exiled from his loved Uraniburg! Our astronomer was not a man to flatter courtiers, and I regret it not. He was also impatient of drivellers; and with a roughish pride, used to repel presumption and the forwardness of meddling officials. Uraniburg, founded by the king, was to a certain extent a place of resort; and it may be conceived, that the men "perfumed of civet," obtained frequently unceremonious audience. Walchendorp, to whom the merit of the active part of the persecution of Tycho, has yielded a most unenviable fame, is reported

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prejudice." And, again, "Most men think indeed, that in these times religion has reached its clearest meridian light, all darkness being dispelled; whence, in that case, those controversies, and that variety of opinion and disputation among learned men professing religion, which make the wars of the pen more frequent and noxious than contests of arms?"

on occasion of a visit to have struck Tycho's favorite poodle with his cane; an insult promptly resented by its master: and it seems that in courts, as in the world, large issues flow from trifling causes. After a mock inquiry, the best observatory the world had ever seen was destroyed; and the most illustrious citizen Denmark has ever possessed, subjected to exile and penury.

Tycho removed to Germany, where he obtained a friend in the Emperor Rodolphus, and an asylum at Prague. Some would have been happy in that new retreat, and have forgotten Denmark. Not so Tycho. His spirit was broken, and he drooped. Rugged though he was, he could not forget Uraniburg; and he always spoke with a doting longing, of the scenes and friends of his youth, the country which had exiled him, and of Huen his little island, the theatre of the play of his dearest affections, the spot with which he associated his labors and glory. Notwithstanding of the kindness of Rodolphus and the companionship of Kepler, he felt as in a strange land; and disease from an accidental cause, carried him off at the age of 55. Sad and too early termination of so glorious a career: many even then were the hearts which when the tidings reached them felt blank, for they knew that a great man was gone. During the last night of his life, he was afflicted by delirium, interrupted by a few intervals, in which he seems to have been employed in reflecting on his career, and surveying his labors; for he repeatedly exclaimed, "I have not lived in vain." Most true! of all the observers of the ancient world, he alone is worthy to stand beside Hipparchus,—they are twin names which should never be dissociated. In awarding him the merit which is his due, let us forget his deficiencies; his failings belong to the humanity of every age,—his greatness was original, and his own!

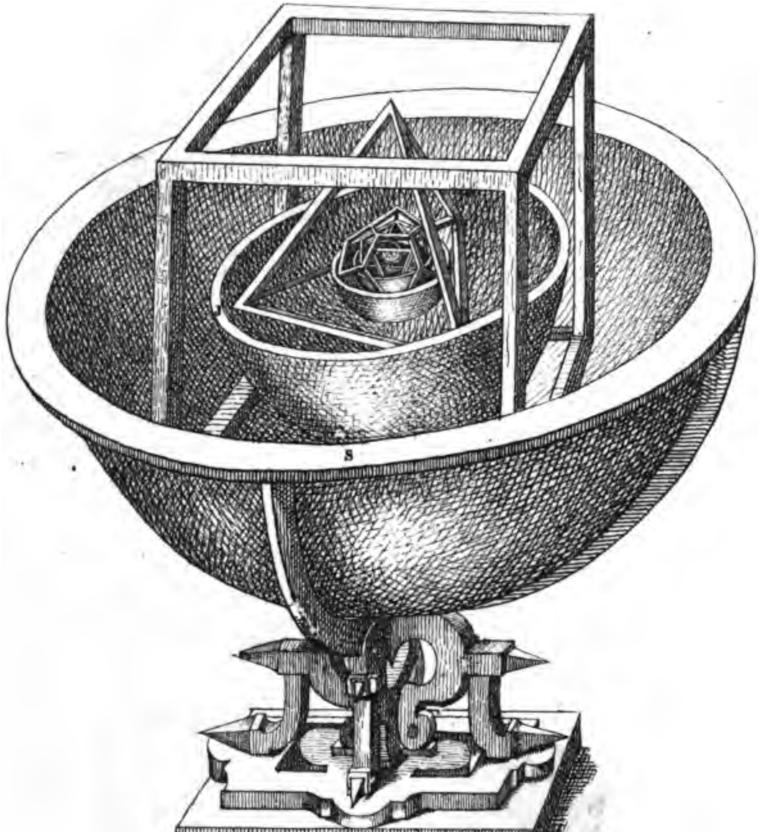
CHAPTER IV.

THEORY PERFECTED.

It cannot have missed the notice of any observer of the course and phenomena of growing knowledge, how feeble in general is the individual, but yet how all powerful is our race. The exertions of single minds are ever tinctured by peculiarity, they are special and incomplete; but it happens in the economy of providence, that what one mind wants another often possesses, that the collective intellect of inquirers, can in the course of generations, bring to the examination of the universe, almost the perfection of every faculty; and thus by effect of combination, knowledge is purified and rendered catholic, and marches stedfastly onwards towards its only true limit, that of comprehending in all its expansiveness, the fine though intricate mechanisms of the Universe. Nowhere perhaps, certainly nowhere within a brief period in the whole history of sciences, is this play and strength of the union of diverse minds, so well illustrated as in the history of Tycho, seen in contrast, as well as connection, with that of the great man whose achievements I am now to review. It appears almost as if the minds of this admirable Observer and John Kepler, were one mind almost perfect—split into two,—each half constituted not by a share or portion of all the faculties, but by the whole of one set of faculties, which subsequently operated in it alone. Tycho's genius lay exclusively with observation; Kepler panted after analogies and relations; Tycho had no power to theorize, and when he attempted it, the failure was miserable; Kepler's enthusiasm made his whole life that of a theorist, divided between the pursuit of mystical relations, and the discovery of some of the noblest truths in the science of Astronomy;—an enthusiasm, however, most diverse from that of the common theorist, who usually seeks not after truth but distinction, and is pleased no better with a great discovery, than a startling and noisy paradox: for, springing from the finest genius, it prompted him ever to search out *real* relations, and until those relations were discovered, never to be at rest. If this ardent, speculative, and often erring mind, had been truly in union, in the same person, with the faculties of the calm, observant, and unphilosophical Tycho, it could not have otherwise befallen it, than to be an instrument of importance scarce calculable towards the reformation of all science: and the truth is, the imperfect union which did take place—the happy association until Tycho's death of the two persons, and Kepler's subsequent and most pious devotion to the memory of his patron and master—has produced an epoch second to none in the importance of the truths it revealed, and which therefore will always be accounted famous.

The mode by which Tycho and Kepler became acquainted and associated, is well deserving of commemoration. After his disgraceful expulsion from Denmark, Tycho received a work from an unknown young man, having the title of *Mysterium Cosmographicum*, or a solution of the mysteries of creation. The work was the first product of Kepler's untutored and fiery genius—full of the most extravagant speculations and conjectures; but

Pl. X.



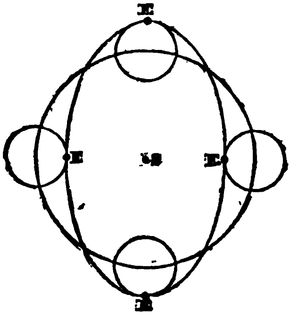
G.W. Lewis Lith:

THE PHANTASY OF A GREAT MAN.

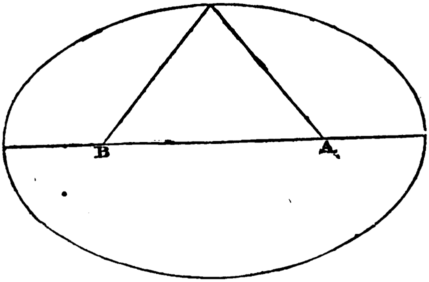
exhibiting a thirst after truth, not the less conspicuous that its author had wholly missed it; together with the most unwearied perseverance. For instance, it was a leading aim of the treatise, to explain why the planets were only six in number: and why they are placed at the distances from the Sun generally assigned to them by Copernicus. In the very proposal of this question, may be remarked the most striking and valuable characteristic of Kepler's mind, viz. an imperishable conviction that law reigns everywhere, and that order and relation may be found throughout every portion of the universe. The considerations, however, by which he thought he had discovered why the planets are only six, and explained the peculiarity of their distribution—are most groundless and whimsical. It so happens, that there are only five *regular solids*, *i. e.* it is possible to make only five solids of different numbers of faces, so that all the faces of each solid shall be equal to each other, viz. the pyramid or tetraedron; the cube or hexaedron; the solid of eight faces, or the octoedron, the solid of twelve faces or the dodecaedron; and the solid of twenty faces or the icosaedron. Now,—referring to Plate X. which is an exact copy of his own scheme—observe the fantasy of his idea of a connection between these five solids, and the number and dimensions of the planetary orbits. The orbit of the Earth, says he, is the ruler of all. Place within this circle, so that the circle may touch it as it surrounds it, an icosaedron or solid of twenty faces. Draw within this solid a circle which will touch its faces internally—*that* is the orbit of Venus! Within the orbit of Venus place an octoedron or solid of eight faces, and, as in the former case, draw a circle within this solid—*that* is the orbit of Mercury. Again, outside of the orbit of the Earth, place a dodecaedron or solid of twelve faces, and around this solid draw a circle—*that* is the orbit of Mars. Outside of the orbit of Mars describe a pyramid or tetraedron, and around this tetraedron draw a circle—*that* (as the figure will now more distinctly show) is the orbit of Jupiter. Finally, outside of the orbit of Jupiter, describe a cube or hexaedron, and around this hexaedron, draw a circle—*that* is the orbit of Saturn. Now, there are no more regular bodies, *therefore* there can be no more planets; and the observed distances of the planets from each other correspond exactly with the intervals between these solids! ! The book from which this extraordinary paragraph is taken, was entitled a *Prodromus* or forerunner—leaving it to be understood that the author meant to give the world an aftercomer, in which doubtless, things still more mysterious would be made equally plain; but thanks to Tycho—thanks on behalf of Kepler and astronomy, this aftercomer never came! The reception given by the Danish astronomer to these strange whimsies was most striking. Tycho was then a veteran, conscious of illustrious deeds, and that his name would endure among mankind. Fretted, too, by recent persecutions under which he smarted most keenly, what, in accordance with man's usual conduct, was the feeling likely to be excited in him by the perusal of the vagaries of an obscure youth, one whose mind was in utter contrast to his own, who was then a dreamer, generalizing on the ground of mystical ideas, and apparently without a notion that science could be reared only on the basis of those labors which consumed the now byegone nights of Uraniburg! Honor to Tycho! Notwithstanding of these temptations, he neither termed that wild young man a fool, nor a visionary, nor presumptuous. He threw at him, from the height of his assured and enduring elevation, not one of those choice epithets of scorn, which small men, on no elevation at all, cast most gladly on those whom they understand not; and, who, after all, may not be erring;—but he sent to the toiling and benighted Kepler, a message of high encouragement, telling him to go on in pursuit of science, and in case the narrowness of his fortune compressed him, offering the aid of his own diminished means. Meditating on this beautiful incident, one of the finest of the kind on record, I have marvelled sometimes, whether Tycho, all so unphilosophical, could yet have appreciated his own deficiencies; and if the idea could possibly have arisen in his mind—even half unconsciously—that it needed only the action of such a genius as was now made known to him, pruned of its excrescences, and habituated to correct its speculations by the test of facts—to rear up by means of the immense materials collected at Uraniburg, almost a new science of the heavens. However it was, and whether he simply intended by that most welcome word, to keep up the fire of discovery in one whose qualities he detected in his very wanderings, honor once more to the noble Dane! Whoever knows the world even now, will appreciate the value and confess the generosity of his conduct: it draws him closer to our sympathies, and enables us, across this interval of ages, and under the dazzling celebrity of the Astronomer, to discover much that should live for ever in the Man.

In consequence of subsequent negotiations, Kepler went to Tycho at his asylum at Prague; where, by virtue of his patron's influence with the Emperor Rodolphus, he was installed as imperial mathematician, with a small salary. Observing the rich stores in possession of Tycho, it appears as if the scenes of another world had burst upon him; and the subsequent and almost exclusive aim of his life was to arrange those multitudes of observations, and to trace among them those harmonies and relations which he believed to pervade all things. And his success was so signal, that no inquirer ever achieved a more complete or definite task. He banished from our idea of the solar system, every shred of hypothesis or vagueness which remained in it; and gave it a breadth as well as distinctness which not only prepared the way, but even necessitated the grand final generalization of NEWTON. I shall describe Kepler's three capital discoveries, in their natural order.

I. Copernicus, as I have already said, did not attack the prevalent idea that the motions of celestial bodies are necessarily *circular* and *uniform ;* and in fact he attempted to reconcile this dogma to the facts already known, by the old Ptolemaic method of mounting small circles on the circumference of large ones—using the artifice, however, in its best and purest form. For instance, he conceived that while the Earth moved round the Sun in a circle, the Earth itself was not on that large circle, but on the circumference of a small one which revolved around its own centre also in a year, so that the earth would *really* describe the dotted path in the subjoined diagram. The

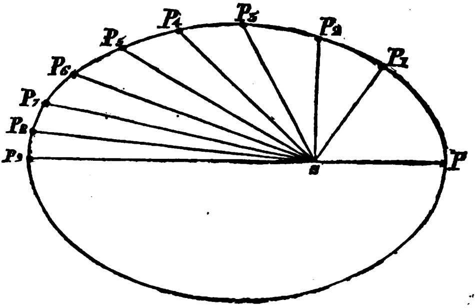


path thus figured was itself no better than an approximation; for the time had not then come in which the true path could be eliminated from observation, inasmuch as Uraniburg had not yet been built. But the time was *now* come! Those materials were garnered which were to show the actual paths of the stars, and to remove every vestige of hypothesis and epicycle, utterly from the sky. Tycho had devoted great attention to the planet Mars; and without delay Kepler threw himself, with unbounded enthusiasm, into the effort to find from these facts the path in which the planet moved. They alone who know the state of practical astronomy in those days, can be aware of the difficulty of this task, of the genius, fine discrimination, and infinite labor, required to evolve it; but no reader can fail to apprehend the value of the truth thereby brought out. There is a curve of an oval shape termed an *ellipse*, whose description is easy. Take a thread, and fix its two ends on a card, so that it may hang very loose between them, and a pencil carried round by the loop of that thread will describe an ellipse. The points A and B, are termed the *foci* of the ellipse—each one being a *focus*. Now Kepler demonstrated that no system—no conceivable complex scheme of circle on circle would correspond with the motions of Mars, which could only



be explained by supposing it to revolve around the Sun in an *ellipse*—the Sun being not in the centre, but in one of the *foci*: and on applying this idea to the case of the other planets, he found—after Tycho was no more, and could not be gladdened by this triumph of Uraniburg—that he had alighted on a GENERAL LAW,—*that the orbit of every planet was precisely such a curve*,—and that now, the simplicity of the system, having arisen above cycles and epicycles—for the first time emphatically appeared! The work on Mars, in which this great discovery is unfolded, is perhaps the most remarkable in the whole library of science. Kepler not only gives the demonstration of the truth at which he ultimately arrived, but also the whole phenomena of his progress towards it,—a progress marked by a thousand odd and false suppositions, but never characterized by the tenacity of the selfish and common speculator, or his adherence to theory for one single moment after it appeared unsupported by Tycho's facts, which, now that his patron was no more, he regarded as a sacred deposit. The work abounds with such passages as the following: "Whilst as just now I am triumphing over Mars, preparing for him a prison from those tables and chains in my equations of the eccentric, lo! they tell me that in sundry places my victory is useless, that war has recommenced, that my enemy has broken his chains, and gone through the gates of his prison!" (he means that the theory at which he has just been laboring, will not explain the motions of Mars in another part of his orbit.) "And so," says he, in another place, "my whole theory has gone off in smoke!" It is not possible to contemplate without interest this prolonged conflict in Kepler's mind. With one pure aspiration burning within him—the desire to comprehend the actual beauty of the universe, behold him ever baffled—the great truth ever escaping him on the moment he imagined himself possessed of it; and yet the ardent man never abating in his enthusiasm one jot, as vigorous on the moment after failure as on the eve of expected discovery, relinquishing his mistaken conceptions with an almost marvellous frankness, but never relinquishing that conviction which had been born with him, that truth and beauty exist—that of all things, the ambition to know them is most honorable, and that to the candid and laborious inquirer will assuredly be accorded the palm! Worthy was such a man to become discoverer,—worthy the High Priest who walked thus reverently to pass within the mystic veil and gaze upon the secret oracles of Nature!

II. The nature of the path in which the planets move around the Sun being now ascertained, and the Copernican system freed from the incumbrance of a supposed necessary circular motion, a new question was stirred in Kepler's mind. The ancients supposed, not only that celestial motions were circular, but that they were *uniform.* Now, observation showed that neither are they *uniform*—*i. e.* in different parts of their courses the planets move with different velocities—velocities, however, which must vary



acccording to some law which had still to be ascertained. The discovery of the principle of this variation was our astronomer's second great achievement; and he owed it also to the facts established by Tycho. It will be easily understood. Let S be the Sun, and the elliptic curve the path of a planet. Also let the distances PP_1, P_1P_2, P_2P_3, P_3P_4, &c. &c. be the parts of its orbit, actually moved over by the planet, in the same space of time—say a month; now the law which connects these different quantities is this—the space or area within PSP_1 is exactly equal to the space or area within P_1SP_2 or P_2SP_3 or finally P_8SP_9. The line SP, SP_1, SP_2 &c. joining the centre of the Sun with the centre of the planet is termed the *radius vector;* and the law now referred to is expressed by saying that *the radius vector of a planet sweeps over equal areas in equal times.* This new discovery was a final and finishing blow to all vagueness and hypothesis. The system of the Heavens was now presented without one hypothetic "axiom"—a pure result of sedulous observation. What Copernicus did in regard to the maxim of the Earth's necessary stability, Kepler had now accomplished in reference to the theory of the orbits: and the system could be realized—geometrically, if I may so speak—in one's mind, without postulating or presupposing any mere *opinion* as its ground. Kepler not only established the truth, but did so under the hindrance, that much reputable rubbish had at the same time to be swept away.

III. As the matter now stands, we see each planet revolving in a fixed orbit harmoniously. The universe had unfolded its simplicity in this respect, and disclaimed aid of artificial schemes; but this was not enough for Kepler. He had felt from the moment when he first knew the stars, that not only must each orb move regularly, and according to law, but that the Planetary System itself must have a *unity of structure*; and this feeling—which had led to his early reverie concerning the five regular solids—did not forsake him now that he had obtained unexpected facilities for unfolding what that unity is. Accordingly, not satisfied with having announced the laws and order of each separate planetary orbit; our astronomer set out afresh, as eager and elastic as before. His labors on this matter are recorded in his book on “Harmonics,” which, as well as the work on “Mars,” is filled with narratives of idle and profitless endeavor. Among other things, he sets the heavenly bodies regularly to music; in which arrangement Saturn and Jupiter take the bass, the Earth and Venus the counter-tenor, and Mercury the treble! But in the midst of all this phantasy, a truth is unfolded, which—considered either in itself or its consequences—is the most important contribution yielded by any man before Kepler, or with one exception since his time, to the science of Astronomy. He showed that the various planets are not unconnected bodies,—each revolving in an *independent* path, according to the foregoing law of their velocities. A fine bond of relation on the contrary involves the whole; and gives the System a distinct and definite *oneness*; exhibiting it, as it were, as an *individual*. The relation is somewhat complex; but *it connects the relative distances of the planets from the Sun with their comparative velocities*; and is expressed technically by saying, that “The squares of the times in which the different planets revolve around the Sun, are proportional to the cubes of their mean distances from his centre.”* Kepler himself knew very well the importance of this great principle, and did not confound it with the speculative whims which, at the same time, he chose to give to the world. “What I prophesied," says he, "two-and-twenty years ago, as soon as I discovered the five solids among the heavenly orbits—what I firmly believed long before I had seen Ptolemy's Harmonics,—what I had promised to my friends in the title of this book, which I named before I was sure of my discovery,—what sixteen years ago I urged as a thing to be sought,—that for which I joined Tycho Brahe and settled in Prague, for which I have devoted the best part of my life to Astronomical contemplations; at length I have brought to light, and have recognised its truth beyond my most sanguine expectations. Great as is the absolute nature of Harmonics with all its details, as set forth in my third book, it is all found among the celestial motions, not indeed in the manner I imagined (that is not the least part of my delight,) but in another very different, and yet most perfect and excellent. It is now eighteen months since I got the first glimpse of light, three months since the dawn, very few days since the unveiled Sun, most admirable to gaze on, burst out upon me. Nothing holds me: I will indulge in my sacred fury: I will triumph over mankind by the honest confession, that I have stolen the golden vases of the Egyptians, to build up a tabernacle for my God,—far away from the confines of Egypt. If you forgive me, I rejoice; if you are angry, I can bear it: the die is cast, the book is written, to be read either now or by posterity—I care not which; it may well wait a century for a reader, as God has waited 6000 years for an observer?"* Our astronomer was well entitled to exult; knowing, in the first place, that his discovery was the fulfilment of the prophecy of all antiquity, for it was the solemn, and to themselves, the inexplicable conviction, that some such relation existed among the celestial spheres, which originated among the inquirers of the schools of Greece and Alexandria, those misty speculations concerning the music of the spheres and the harmony of numbers. And Kepler also judged of the importance of this law to future science; he saw in it our first hint of some simple and universal order among these various motions.

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* See note A at the close of the volume.

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* From the *proemium* to one of the books of the work on Harmonics. I have given Mr. Drinkwater's translation.

Such were Kepler's three laws. They comprised, it will be observed, a complete chart of the Heavens. Sketching and defining the motion of each planet, they also established the relations of all these motions, and thus likewise sketched the system. Nothing in this field was left to future inquirers: and Kepler will always enjoy the proud distinction of being the LEGISLATOR OF THE HEAVENS.

The character of KEPLER is emphatically to be *loved*. His morals were most pure;—you choose him as a dear friend. How candid! How deceitless! His attachments were disinterested and immovable; he was a good father, a kind husband, a most devoted son. Great was the intellectual activity required to perfect the foregoing three laws; but Kepler's extended much farther. He contributed to Optical Astronomy, and to many other separate parts of science: and he wrote much besides that to which I have adverted, of a most whimsical kind. The comet, for instance, best known by its having HALLEY as a patronyme, appeared in Kepler's time, and attracted great attention. Our astronomer also observed it; and deemed that, like all comets, it was a monstrous birth from the *heat* and *moisture* of the skies! Not unfrequently, in reviewing his character, such phantasms have been charged seriously against him, and used to abridge his fame. The fact is, the mind of Kepler could not be at rest—it could not partake, at least before his time, of the fabulous sleep of eternity. His wild speculations were only the results of an organisation so active; joined to this, that his powers led him to *generalize*, not to observe. His dreams are the mere action of such a mind constantly pressing in the van of existing knowledge, and boldly invading the unseen; and it must never be forgotten, that so far from inducing him to act as a distracter of more sober inquirers, or to withstand their conclusions, no light in regard to the Universe came out from any quarter which he did not receive with enthusiastic eagerness. How grand the spectacle of a Mind thus restless—thirsting with unquenchable appetite after beauty and harmony! Never was there a finer example of a spirit too vast to be satiated by the few truths around it, or one which more emphatically foreboded a necessary Immortality. Illustrious man! Thrice, since he departed from our world, has that wandering comet looked on us from the skies, beaming each time with its misty ray upon the graves of the generation which last beheld it, and ever marking the progress onward of a new generation in all that belongs to a knowledge of the realities of things. Many prejudices have passed away during the course of these three returns, inasmuch as the meanest of us can now turn round and smile at Kepler; but this only at what Kepler *was*—for who shall say, that while we have been advancing with step slow but sure, his great Mind has partaken of no progress? What he has done since then, what he has thought and what discovered, is recorded not on earth, but in some sphere less contracted, fitter for the correction and satisfaction of his mighty capacities; where, it is scarce doubtful, he will have been rising, ever rising, even like the bird of Jove—sailing through his native Element, and satiating his eager Spirit by gazing ever and more closely on those pure fields of Light, which surround the THRONE OF GOD!

SUPPLEMENTARY CHAPTER.

FARTHER CHARACTERISTICS OF THE MOTIONS OF OUR SYSTEM.

Thus, after traveling through the history of more than twenty centuries, have we, across much difficulty and struggle, arrived at the final solution or law of those three great classes of facts concerning the motions of the celestial orbs, which I specified, at the outset of our course, as the staple and foundation of Astronomy. On that long labor which had engaged as great an amount of intellect, as was ever employed on any portion of the Universe, Kepler placed the top-stone, leaving in one respect, nothing to be desired. But the three laws, of which he obtained possession, do not, with all their importance, include the whole characteristics of the planetary movements. There are at least other three general classes of facts not involved in them, and which, as will afterwards be seen, hold no subordinate place among the essential features of the mechanism of our system. These, in supplement to the previous exposition, I shall now briefly explain; but the remarkable part they play in binding our system into one grand Unity, will not be understood until nearly the close of the whole inquiry.

1. *The ovals or ellipses, in which the several bodies*

move, are almost circles, i. e. the oval, although quite defined, is never elongated or drawn out,—its breadth is nearly as great as its length. Some of the orbits are more elongated than others; but the general fact now stated holds good in every case, whether with regard to planet or satellite.

2. As represented in Plate I., the paths of the different planets are nearly coincident with the apparent path of the Sun, *i. e.* with the real path of the Earth. This requires further explanation. Suppose the Sun placed in the centre of a table of infinite dimensions, and fancy the Earth rolling around him upon the surface of that table,—the other planets will not revolve precisely upon the surface of that table, but *they will never be far from it; never much either above or below it.* Again, the Sun's equator, *i. e.* the line half-way between the Poles of the axis on which his huge mass rotates, is not far from the plane of the same table; so that, if we conceive the table to pass through the Sun's centre and equator, instead of through the orbit of the Earth, the paths of all the planets and satellites (excepting the satellites of Uranus) will nearly coincide with it; and we may, therefore, state as a general law, that the planets, and (with the foregoing exception) satellites, *move in orbits almost in the plane of the Sun's equator.* The law now referred to must have been remarked by the earliest observers of the Heavens, for beyond a narrow zone, extending somewhat on either side of the Sun's apparent path, no planet is ever seen—the other vast regions of the sky being occupied by fixed stars alone, or their peacefulness disturbed only by some wandering comet. Hence, too, the beauty of "conjunctions," or of those not very rare aspects of the Heavens when a few of the planets are grouped within a close neighborhood. Although sufficiently fanciful, it was an ingenious

and not unpleasing idea, and when Creation occurred these bodies were launched from the same quarter of the sky, so that, by calculating back to the era of this grand conjunction, we might ascertain the commencement of the annals of the Material Universe!

3. All motions of *revolution* in the system *take place in the same direction*, *i. e.*, the planets move around the Sun, and the satellites around the planets to which they belong, *from East to West*. To this there is no exception whatever, but in the satellites of the wholly enigmatical Uranus,* whose revolutions are *retrograde*. The same singular uniformity is also discernible in the *rotations* of the planets. The Sun rotates upon his axis in the same direction in which the planets move around him; and *every planet whose rotation has been discerned follows the same law*. Farther still, *the satellites rotate also in this direction*. Our Moon, for instance, revolves on its axis from west to east in the precise time in which she accomplishes a lunation, or in one month; and every thing known concerning the moons of Jupiter and Saturn is agreeable to the same law. We are thus conducted to a most striking proposition,—*All the motions* (with one exception), *within the solar system, whether of revolution or rotation, take place in the direction in which the Sun rotates on his axis.*

That three laws like these can result from *chance*, were a supposition too monstrous for belief. Considering the relation of the phenomena they include to the Sun's Rota-

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[*] It is perhaps not generally known that what we have yet been able to learn of this planet, is not consistent with the idea of its moving in an elliptic path. Some great discovery is yet awaiting us in that quarter.

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tion and his Equator—for all the motions are in the direction of his Rotation, the orbits are nearly in the plane of his Equator, and almost as circular as the path of a point on his vast surface,—the suspicion obtrudes itself that some profound secret of Nature is before us in dim shadow—probably a first hint of *the parentage of these subservient orbs.*

The resolution of a problem like that now indicated will not indeed be completed, until we have explored the profoundest secrets of the planetary scheme; and reached that central and commanding point of view from which all its phenomena appear regular and co-ordinate. But though the achievement be remote, the contents of the part of our work I am now closing, viz. the history of the final and certain, although painful evolution of truth—forbid us to be so "unphilosophical as to despair."

PART II.

THE PHYSICAL CONSTITUTION OF THE SOLAR SYSTEM, AND OF THE BODIES WHICH COMPOSE IT.

INTRODUCTION.

We pass now to a different order of contemplations. Hitherto, the planets whose mazes we have tracked, have seemed as mere points of light adorning the midnight Heavens; or, if hints have been dropped concerning their individual character and significance, they have only aroused curiosity, and incited us to trace farther and more expressly the physical nature of each orb, and its peculiar manner of being. The varieties now soliciting our regards, far transcend, in number and degree, the diversities in motion we have just discussed; so that perhaps it were vain to hope that they also may be reconciled within principles so simple as Kepler's laws, or that we shall ever understand the close brotherhood of which they unquestionably partake. Our inquiries, however, will not be wholly vain. We shall discern the certainty of such brotherhood, although we yet know not its precise nature; traces of grand physical laws environing even this wonderful variety, will burst upon us; and thus we shall be prepared for a better understanding of the true unity of Things.

CHAPTER V.

THE LEADING AND GENERAL CHARACTERISTICS OF THE BODIES OF OUR SYSTEM.

IN the first place, let us realize the Solar System as a whole;—a system which unfortunately cannot be the subject of any pictorial representation of practicable dimensions. Diagrams like Plate IV. may exhibit its general arrangements, and toy-orreries arrest the eye of childhood,—but so different, so incommensurable with each other are the quantities entering into its constitution, that in respect of the true relations of the Sun and Planets, the idea impressed by any picture, graphic or mechanical, is most inadequate and deceiving. This will appear with sufficient distinctness if my reader ponder on the following approximate illustration of the dimensions referred to, which I have borrowed in substance from the treatise on Astronomy by Sir John Herschel. Conceive the Sun represented by a globe two feet in diameter;—at eighty-two feet distance put down a *grain of mustard seed*, and you have the size and place of the planet MERCURY, that bright silvery point which is generally enveloped in the solar rays: at the distance of one hundred and forty-two feet, lay down a *pea*,—it will be the similitude of VENUS, our dazzling Evening and Morning Star. Two hundred and fifteen feet from the central globe, place another *pea*, only imperceptibly larger—that is Man's WORLD—(once the centre of the Universe!)—the theatre of our terrestrial destinies—the birth-place of most of our thoughts! MARS is smaller still—a good *pin's head* being his proper representative, at the distance of three hundred and twenty-seven feet: the four small planets, VESTA, JUNO, CERES, and PALLAS, seem as the least possible *grains of sand*, about five hundred feet from the Sun; JUPITER as a middle-sized *orange*, distant about a quarter of a mile; SATURN with his ring, a *lesser orange* at the remoteness of two-fifths of a mile: and the far URANUS dwindles into a *cherry*, moving in a circle three quarters of a mile in radius. Such is the system of which our puny Earth was once accounted the chief constituent,—a system whose real or absolute dimensions are stupendous as may be gathered from the size of the SUN himself—the glorious globe around which these orbs obediently circle; which has a diameter nearly four times larger than the immense interval which separates the MOON from the EARTH. Compare this mighty diameter, or the space of *nine hundred thousand miles*, with the assumed diameter of *two feet;* and the proportion will tell by how many times the supposititious orbit of Uranus should be enlarged! The dimensions of the system surpass all effort to conceive or embody them;—and yet a wider knowledge of the Universe shews that they belong only to our first or smallest order of INFINITIES.

Now, even in this general view of our system, we recognize the truth that these individual orbs *cannot* be the same in constitution, but that a singular internal diversity must characterize them, flowing from at least three manifest sources.

I. Of the Sun's train of eleven planets—all regularly revolve around him, and, so far as ascertained, also rotate on their own axes—the former motion constituting the year of each orb, and the latter its succession of day and night; but how various are the absolute *durations* of these important periods in the different bodies! The following table compares them with those of the Earth.

PLANETS.	Period of Rotation, or nearly the length of a Day and Night.		Period of Revolution in length of Years.		
	Hours.	Minutes.	Years.	Months.	Days.
MERCURY,	24*	6	0	2	28
VENUS, .	23	21	0	7	15
EARTH, .	23	56	1*	0	¼
MARS, .	24	39	1	10	21
VESTA, .	unknown		3	7	21
JUNO, .			4	4	13
CERES, .			4	7	11
PALLAS, .			4	7	17
JUPITER, .	9	56	11	10	17
SATURN, .	10	29	29	5	24
URANUS, .	unknown		84	0	27

In judging of the probable effect of this signal variety upon the internal economy of the several planets, we must either abandon speculation as vain and impossible, or be content with a few guesses drawn from a supposed analogy with the Earth. The latter course indeed is almost equivalent to the former, for it conducts us among circumstances where we are only bewildered, seeing that imagination fails in the effort to combine and embody them. How, for instance, can that contrast be pictured, which subsists between the two exteme bodies of our system, URANUS and MERCURY,—the one hurrying through its restless cycle of seasons in three months, and the other spending on the same relative change eighty-four terrestrial years? A tree in Mercury—if such there be—would gather around its pith or axis three hundred and thirty-six of those well known circular layers, in a time during which the sluggish vegetation of Uranus would only have deposited one: and a full and burning lifetime, made up of rapid sparkling joys and acute sorrows, would, in so close neighborhood of the Sun, be compressed within a space hardly adequate on Earth to lead youth to its meridian,—while at that outer confine a slow pulse and drowsy blood might sustain for centuries a slumbering and emotionless existence! The question is farther complicated if we refer to the rapid succession of day and night in the remote planets; perhaps modifying by the activity it excites, the comparative torpidity due to the length of the year. We can form no notion of the physiological consequences due to a recurrence of day and night within the brief period of nine or ten hours.

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* For the sake of simplicity the year is here accounted exactly 365 days, and the month 30 days.

II. The very different *distances* of the planets from the Sun is a second obvious source of remarkable contrast. Those proportionate distances may be guessed from the illustration at the commencement of this chapter; but Fig. 2, Plate XI., will further aid the imagination. It shews the comparative size of the Sun when seen from the different bodies in our system,—dwindling gradually from the mighty globe visible at Mercury, to that comparatively small orb, which enlightens the landscapes of Uranus. It is computed, that at Mercury the Sun shines

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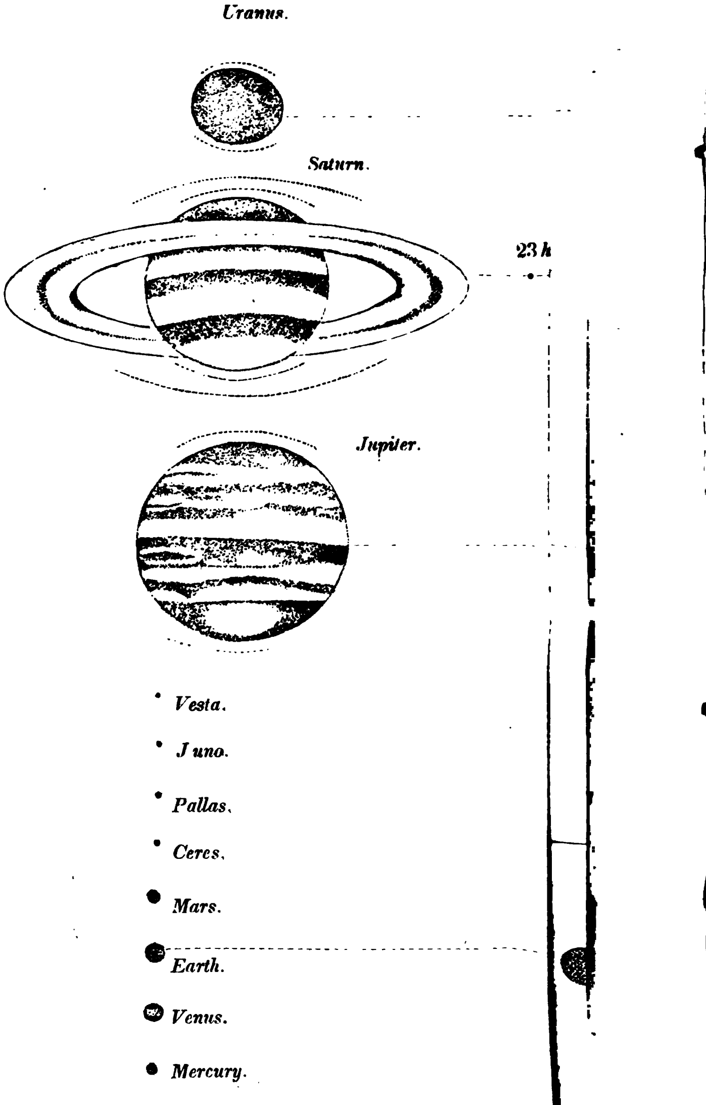
A


Uranus.
Saturn.
23 h
Jupiter.
Vesta.
Juno.
Pallas.
Ceres.
Mars.
Earth.
Venus.
Mercury.

with seven times the intensity experienced on Earth, and that at Uranus his radiation is at least 330 times weaker than with us. Between MERCURY and URANUS, therefore, besides the difference occasioned by the rapid and slow alternation of seasons, there is an actual disproportion in the quantity of solar light shed upon them of upwards of 2000 to 1. And yet Uranus is not obscure nor its plains benighted. The light of our full moon has been computed as about 300,000 times weaker than that of the meridian Sun, so that the light-giver can bestow, even on his remotest attendant, as much light at noon-day, as if nearly 1000 of our moons were shining in its sky. In these remote regions we likewise find, as if in some compensation, a singular extension of that provision which so much adorns our Earth—the provision for throwing part of the solar light on the dark hemisphere of the planet by reflection from *moons*. In Mercury, Venus, and Mars, the midnight vault is bespangled only with stars; but Jupiter has four moons, each larger than ours, constantly circling around him, varying his skies by their beautiful and ever-changing phases; Saturn has seven; and, according to Sir William Herschel, Uranus has six. The comparative distances of these secondary bodies or satellites, to which incidental allusion has already often been made, are exhibited in Plate XI.,* and I have written over each, the period of its revolution around its primary orb. Excepting in three cases—that of the seventh satellite of Saturn, and the fifth and sixth of Uranus—these periods are all shorter than one of our lunations; so that, if the size of their orbits is regarded, we may gather a faint idea of the intense activity of these interesting systems, and of the rapidly changing series of phases and eclipses they must incessantly display.* The curious speculator will perhaps bestow a thought on the complex schemes of *tides*, &c. which must spring out of the conjunctions, oppositions, and various relations of these subordinate bodies.

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* The seventh satellite of Saturn, and the sixth of Uranus, are at *twice* the represented distances.

III. Lastly, there are striking discrepancies, among the *magnitudes* of the planets, which, unconnected with the relations between their several distances from the Sun may be pictured with considerable accuracy. Plate XI. attempts to accomplish this,—where A B is the Sun's supposed diameter: it is still faulty however, with regard to the Asteriods between Mars and Jupiter; for no point, short of a mathematical one, could exhibit their relations to a Sun of that size. Besides the mere consideration of their bulk however, there is one very important characterstic. The Plate alluded to exhibits merely their diameters or relative *sizes;* without regard to their relative *weights*. A subsequent part of our investigations will very clearly show how these weights have been ascertained with marvellous accuracy, how the planets have been placed in the most delicate of balances; and the comparison in each case of the *weight* with the *volume*, throws a most singular light upon the *description of matter* of which the several orbs are composed. The facts are classed in the following table.†

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* Note B.

† The Numbers are given approximately only, to avoid large fractions.

Name of the Orb.	Size of the Orb compared with the Earth.	Weight of the Orb compared with that of the Earth.	Comparison of the Weight of the Orb with that of a Globe of Water of equal dimensions.
THE SUN,	1,380,000	355,000	$1\frac{1}{5}$
MERCURY,	$\frac{1}{16}$	$\frac{3}{20}$	$17\frac{7}{10}$
VENUS,	$\frac{4}{5}$	$\frac{9}{10}$	$5\frac{1}{5}$
EARTH,	1	1	$4\frac{9}{10}$
MARS,	$\frac{1}{5}$	$\frac{1}{8}$	$3\frac{3}{10}$
VESTA,	$\frac{1}{5000}$	...	...
JUNO,	$\frac{1}{200}$	...	...
CERES,	$\frac{1}{125}$	...	...
PALLAS,	$\frac{1}{55}$	...	...
JUPITER,	1,300	338	$1\frac{1}{10}$
SATURN,	990	95	$\frac{1}{2}$
URANUS,	80	17	1

If the varying periods of the revolutions of the planets and their varying distances from the Sun intimate a necessarily diverse *external* aspect, the right interpretation of the previous table will emphatically show that the *internal* varieties cannot be less striking, and that only a fragment or stray leaf of existence is found within those four cardinal points which are the corners of our world! For observe the necessary and essential differences of such globes in *material* composition. The matter of which Mercury is made up is nearly four times heavier than that which composes our world, while Saturn is as light as a cork! What can be the surface of Mercury—where the locality of water in Saturn? And, again, how great the influence of such varieties upon the forms of organization! Upon the weight or mass of each planet, depends in chief part the *weight* of a body at its surface. Now the size attained by organized families must be regulated ultimately, by the power of the materials of which they are composed, to resist the depressing force of their own weight. If, for instance, the enormous Baobab—that grandest proof of the strength of the vegetable fabric, were suddenly to become twenty times heavier than it is—or if a North American pine received an equal addition of weight, the fibres which sustain them would be bruised and they would fall crashing to the ground. So, in the animal world, the Elephant or the old Magatherium, are, perhaps, the mightiest fabrics which can be sustained by the utmost strength of bone: whence it may be, among other causes, that the drying up of interior lakes—on the waters of which they often reposed their enormous weights—has caused the disappearance from our world, of the gigantic Dinotheria:—Now, give a man twenty-seven times his present weight, *i. e.* transport him to the surface of the Sun, and every bone which supports him would crumble in one instant to powder!—But if, on visiting the Sun, we must consent for security to be transformed into some beetle or caterpillar; a visit to Vesta would soothe the vainest, for there—on a planet whose whole surface is not greater than the kingdom of France—gigantic dimensions are possible with our present structure, and vertical leaps of some sixty feet would assuredly gladden the heart of the most ambitious athlete! . . It were the easiest undertaking to push these conjectures farther;—perhaps they already verge on the ludicrous. It is one great use and function of all such speculation to arouse due conceptions of the *variety* of the Universe—a variety co-extensive with its vastness—but through which, law unquestionably prevails and rules and orders all. How worthy of the Being on whom the CREATOR has bestowed the great gift of Reason, to seek humbly to trace his footsteps through this maze; how fortunate that, even in our small World, there is enough to prevent the variety from being distracting—enough to impress the reverent mind with true notions of *Him ;* notions which will not be altered, but only enlarged, and purified when the shutters are farther opened, and more light has come !

Resuming the whole, it will be noticed that the circumstances necessitating these varieties—external and internal—in the planetary constitutions, may be arranged into four classes, viz:—1. *The different times of the revolution of the several orbs ;* 2. *Their various distances from the Sun ;* 3. *The diverse period in which they rotate on their axes ; and,* 4. *Their different magnitudes and densities.* Now it is clear, from Kepler's third law, that the two former of these sources of variety are closely connected, and therefore may be reckoned as one single cause ; but, where the relations of the others ? why are the planets at these peculiar distances from the Sun ?* why do they rotate so variously ? what is the law of their magnitudes and densities ? . Before we close, some light, although very faint, will be thrown on part of these inquiries ; and, in regard of the others, let us recal the sentiment of the old Greek, that the "divinities do not act inexplicably," and with stout heart push boldly, but warily on.

* Note C.

CHAPTER VI.

CHARACTER AND CONSTITUTION OF THE INDIVIDUAL PLANETARY BODIES.

HAVING thus found, in the general arrangements of the planetary bodies, and the leading characteristics of their constitutions, ample reason to believe that their whole framework is most various, we naturally point the telescope to each orb, so that these varieties may be seen. Alas! potent though this instrument is, it has yet yielded very little, either to confirm or invalidate our expectations: but nevertheless, what it has done is of high import; for it has revealed the prevalence of several physical peculiarities, and the *special* character of other phenomena visible on the Earth. It has besides disclosed much to aid us in our approach to a final generalization concerning the origin of visible things.

The SUN, distinguished so remarkably from the members of his train, demands a separate examination, so that I shall exclude him from this chapter. URANUS and MERCURY I also pass over in silence, the first being so concealed by distance, and the other by the veil of the Sun's light (although elevations and greyish spots have been seen on his disc, when his darc side was turned towards us), that attempts at description were only idle and deceptive.

§ 1.—*Mars and Venus.*

Nearest the Earth on either side, are two planets, under circumstances not greatly different from those which influence our globe, and therefore probably having many sympathies with it. I proceed to narrate what we know of these.

Of MARS, our precise knowledge is little. It has an atmosphere not unlike that of the Earth—certainly not more extensive, and probably clearer. Its day and night are almost of the duration of ours, and its surface is divided into continents and seas, whose complete outline we have not been able to trace. Plate XII.—for which Astronomy is indebted to the accurate and graphic pencil of Sir John Herschel,—shews one side of Mars. "The darker parts are seas, and the land is characterized by a reddish color, undoubtedly springing from its chief geological formation." The bright spot at the top, is at the pole of Mars; it disappears as the Sun shines on it more directly, and there can be no doubt that it is a reflection from *snow.** Rain and sunshine are therefore there, mornings and gorgeous sunsets, with their tongue of flame shooting across the waters; also in Mars there is the eternal flow of the ocean! Its tides, however, must be gentle, such as wash the isles of Egean." The lower figure in Plate XII. shews the appearance of one side of the Earth at a corresponding distance, and speaks to the eye of its similitudes with Mars.

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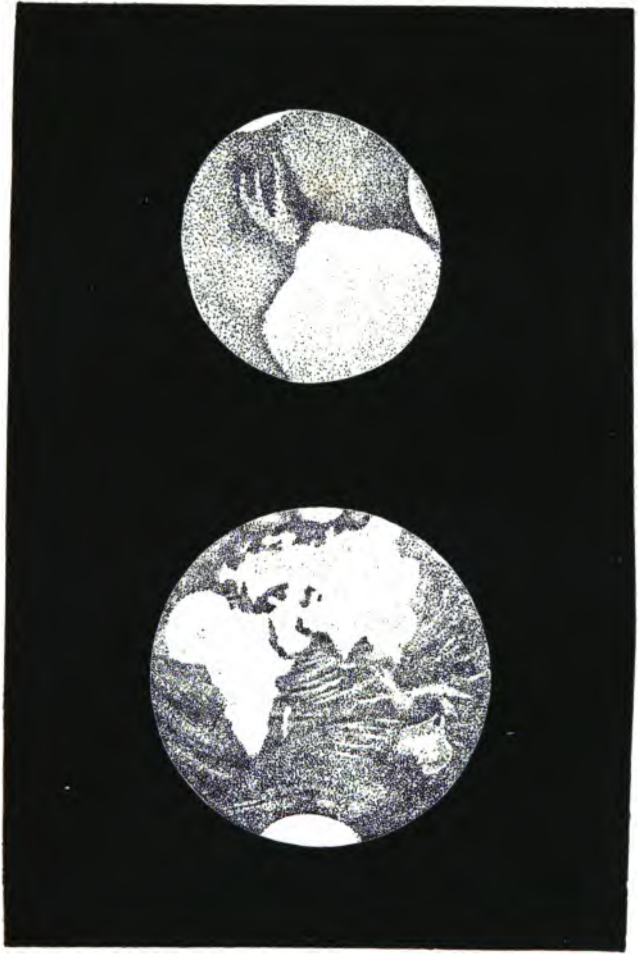
*MM. Baer and Mädler of Berlin have lately given delineations of the whole orb. We shall soon have a complete map of MARS. The division of this planet into land and sea shows that its profile is *irregular,*—in other words that there are *elevations* in it.

MARS **Pl. XII**



THE EARTH.

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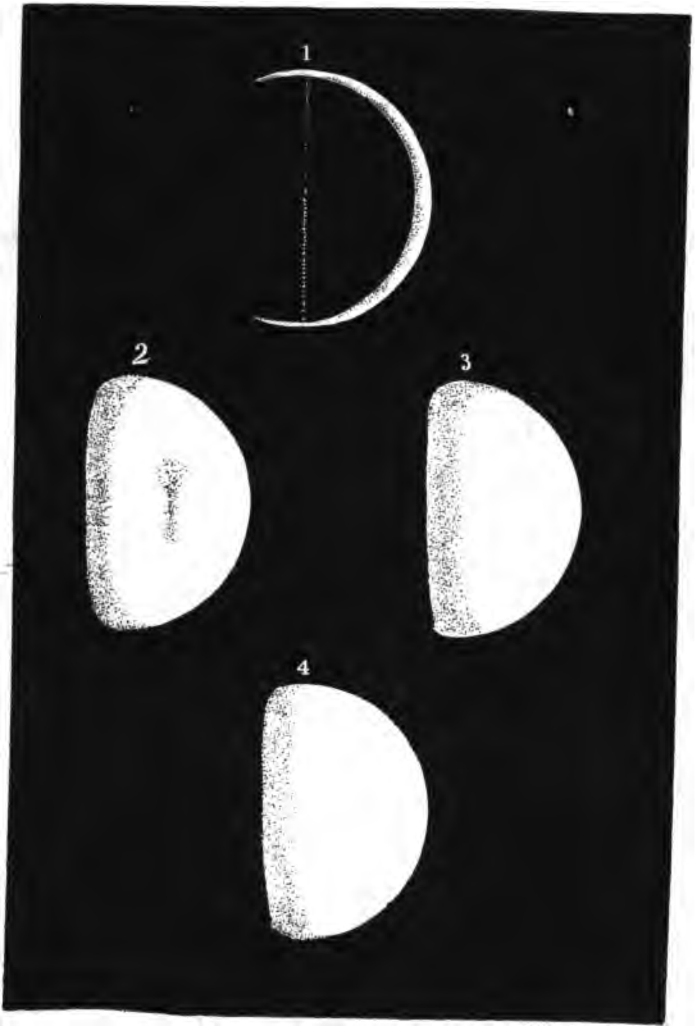
VENUS IN PHASE. *Pl. XIII.*



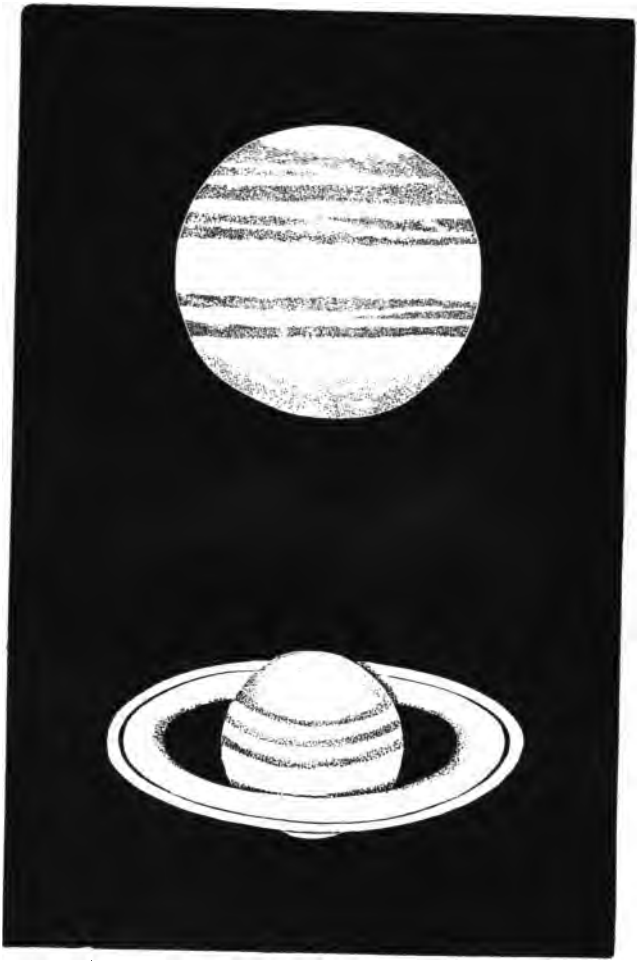
Venus has likewise resemblances to our world. Of her body we know less than might be expected from her proximity, owing to the denseness of her atmosphere; but every thing known of her convinces us, that she is not more unlike the Earth than Mars. First, she has a large atmosphere. Schroeter distinctly discerned her twilight, or the stretching of a faint light beyond the semicircle, which ought to be alone directly enlighted, as is represented in Plate XIII. Fig. 1, where the dotted line marks the natural terminus of the influence of the Sun's rays. Secondly, her atmosphere has clouds, so that we infer the existence of water below, out of which the vapors are drawn. Fig. 2 shews the spots occasioned by these clouds; they are exceedingly variable, like the fleeting vapors in our own sky. Lastly, there are great inequalities upon the surface of this planet—mountains probably in ridges, and certainly much higher than any on the Earth. Schroeter detected these masses by several infallible marks. In the first place, the edge of the enlightened part of Venus is *shaded*, as seen in the accompanying representation of her, and as the Moon appears when in crescent even to the naked eye. These shadows are unquestionably flung from mountains, and are naturally best seen on that part of the planet to which the Sun is rising or setting, where of course they are longest. But besides, her edge shews *marked irregularities*. For instance, she often appears rounded at the corners as in Fig. 3, owing undoubtedly to part of her disc being rendered invisible there, by the shadow of some line of eminences; and at other times, as in Fig. 4, a single point appears detached from the planet,—the top of a high mount, illumined across a dark valley. These appearances, too, are *regular and* FIXED; the same point is always seen in the same circumstances, and Schroeter determined the time of the planet's rotation, by watching the recurrence of such phenomena. Venus, then, is related closely to the Earth; as in Mars, a law has operated in this planet evolving continents and oceans; and that mighty upheaving cause which raised our Alps and Cordilleras from the bosom of our own globe, has also broken up and variegated her plains. We shall have farther reason to consider the operations of this force as a grand, and probably universal cosmical phenomenon.

§ 2. *Jupiter and Saturn.*

We turn now to the noblest constituent of the planetary system. The planet JUPITER is, with the exception of Venus, the brightest orb in our heavens; and, when narrowly examined by telescopes, he far surpasses in grandeur every other body connected with our Sun. In diameter more than ten times exceeding the Earth, his surface must be equal to upwards of one hundred worlds. In an ordinary telescope he appears as large as the Moon, attended by four moons of his own, circling around him in periods already referred to. Not subject to seasons—for his axis of rotation is almost perpendicular to his orbit—he is a type of Being strikingly different from the orbs whose characteristics we have unfolded; but there are intimations withal, of some correspondence between Jupiter and these nearer globes. The mean density of the mass of this planet being not much more than the weight of water, we cannot conceive that water, if developed in Jupiter, occupies the position in which we find it on Earth. It rather ought to be an inferior stratum. But there is little doubt of the existence of *some* fluid in the planet's surface; for its atmosphere has *clouds*, which are generally cast into

Pl. XIV.

JUPITER.



SATURN

NIV

curious forms. It seems probable that a current sets from the poles to the equator of Jupiter, as on this earth; and that the very operation which produces our trade-winds (see figure of the Earth in Plate XII. where the apparent aspects of these winds are exhibited) throws them into parallel currents producing bands or belts. This peculiarity of Jupiter is represented in the upper figure of Plate XIV., where the belts are shown as an ordinary telescope will represent them. This account of these curious formations is, of course, quite hypothetical, but it is the most plausible yet proposed. The dark belts are probably openings in the atmosphere, showing the actual body of the planet—the strata of clouds being the intermediate and brighter banks. On the dark portions fixed spots are also frequently seen, probably *mountains*. . . . It were vain to pretend to a more minute description of this splendid planet. Hitherto we have obtained only a glimpse of the existence there of a grand and novel scheme of Being—certainly related to this Earth, although, in so far as we know, very distantly.

The orb next engaging our attention is the most extraordinary in the system. SATURN, nearly as large as Jupiter, accompanied by seven satellites, of which one is as large as Mars, marked also by belts, which, however, are far more invariable than those on Jupiter, and consequently refer to more fixed portions of the planet's constitution, —is also surrounded by a magnificent girdle or Ring, or rather by a number of concentric and connected rings in the plane of his equator. This most extraordinary formation, disovered by Galileo, but first analysed and comprehended by Huyghens, is represented in one of its aspects in the lower figure of Plate XIV. It is hardly possible to conceive a grander spectacle than this ring to an observer on the body of Saturn—sometimes as a noble girdle stretching almost around his horizon, and elsewhere, as a magnificent arch spanning the whole sky. In so far as we have distinctly ascertained, the ring is in two divisions, the breadth of the outer one being ten thousand miles, that of the interior seventeen thousand, the space between the rings eighteen hundred, the space between the planet and the interior ring nineteen thousand, and the thickness of the ring, according to Sir John Herschel, about a hundred. I have little doubt that a greater number of divisions will yet be discovered in this object: nay, may it not one day serve in some manner *as a section of the interior of a globe, or rather as a* SLICE *of a globe—exhibiting concentric strata of different densities, between which deflagrations may have taken place, and caused their separation.* But whatever its minute constitution, the existence of this Ring is a new fact in the solar system; one, however, not capricious or inexplicable, but which will unquestionably altogether harmonize with the system's origin, and receive its full explanation as soon as we know the process which brought these co-ordinate orbs from the womb of Night. I must mention, in conclusion that the ring is not always visible. Owing to the different relative position of Saturn and the Earth, it appears sometimes quite open—and at others it presents its mere edge to us, which is too thin to be at all seen. The shadow of the ring causes night on a certain belt or portion of Saturn *for eighteen years at a time!*

§ 3. *The Asteroids.*

Our glance is next arrested by those curious bodies between Mars and Jupiter—the four new planets, VESTA, JUNO, CERES, and PALLAS—distinguished from all the other orbs by very marked characters. They are by very much the smallest group of bodies in our system. PALLAS, the largest of the four, being not greater than our Moon; and VESTA, the least, not exceeding in surface probably the kingdom of Spain! Accompanied by atmospheres, these little bodies are in this respect similar to our Earth, but we have hitherto obtained no facts whereon to ground a hypothesis of farther analogy. One circumstance connected with them is very peculiar—*they are about the same distance from the sun, and their orbits cut each other;* while, as is well known, the other planets are separated from each other by vast intervals. The inference is not unwarranted that, probably they are *one formation*, answering in the history of its birth to the act, whatever it was, which produced *one* of the other planets, and merely differing from that act, *in not consolidating the produced matter into one mass.* We may be quite satisfied that in this variety there is still a perfect unity, and that these exceptions to the usual character of the planetary formations are no *anomalies*,—nay, their use is to enable us to take a larger grasp of the fundamental character of our system, to free our views from *specialty*, and guide us to that central point from which all varieties will seem co-ordinate. What I have already written, shows that we are still far from that term; but the telescope is improving so rapidly that the time cannot be distant in which facts will be accumulated sufficient to encourage and sustain extensive generalizations.

§ 4. *The Moon.*

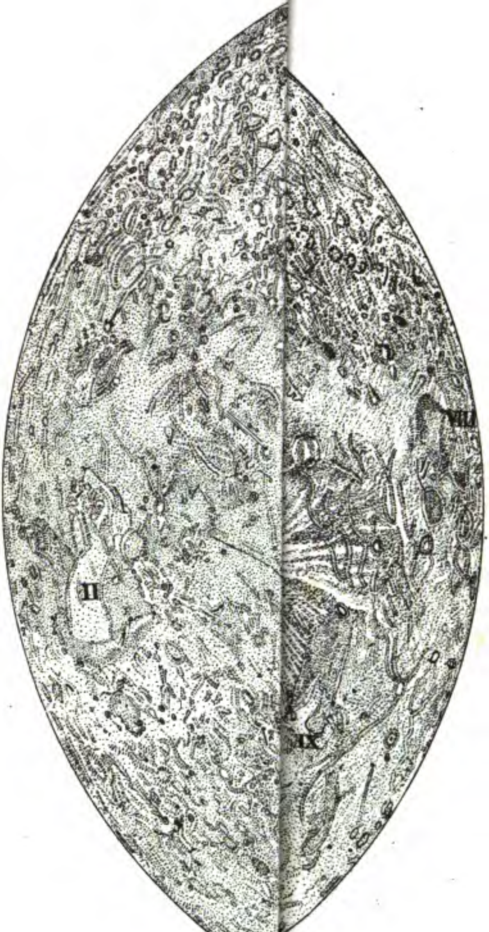
We now reach an orb linked to the earth by close relations, separated from us by only a small distance (240,000 miles,) and whose constitution has been narrowly scanned.

But as she also exists quite out in external space, and is far from the influence of such physical agencies as are merely terrestrial, she is well suited to enable us to separate what is only peculiar to this earth from what is *cosmical* or universal in planetary matter, and by aid of the few hints elsewhere obtained, to guide safely onward a few steps, our theories of the Universe.

In describing the MOON, I shall pursue the following order—noticing, first, Those characters which are peculiar to her as a *satellite;* secondly, Those parts of her constitution by which she is contrasted with the Earth; thirdly, Those features in which she so far resembles our planet; and, lastly, Some appearances whose significance is yet wholly unknown. That I may address the reader's eye, and place him as if in sight of the luminary of our nights, I shall illustrate my description, graphically, in the fullest manner.

I. The Moon has one very singular feature, apparently belonging essentially to her as a satellite, since it distinguishes every other satellite with which we are sufficiently acquainted. *She revolves on her axis in the same time in which she revolves in her orbit round the Earth,*—in other words, the length of one day and night in that orb, is precisely one of our months. The rotations of Jupiter's satellites also nicely correspond with the periods of their revolution around that planet, and all we know or suspect of the attendants on Saturn, is in obedience to the same law. Why this is so, is unknown—it is one of those dark points which stir us to profounder inquiry concerning the scheme in which we are; but it is not difficult to trace some of its effects. Owing to this arrangement, the Moon always turns the same face towards the Earth. As she goes

Pl. XV.



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her monthly rounds, she revolves proportionally on her axis—each spot keeping its relative position towards us; and if it were not that her velocity in her orbit is slightly irregular, while the rotation is perfectly regular—the effect being to show us sometimes a short way on the other side of her borders—we should never see any thing of her opposite hemisphere. If there are inhabitants on the satellites, how strange that they who dwell on one half of their surfaces can never see the central body around which they move, unless after a circumnavigation of their globe! One can hardly conceive the strangeness of the Astronomies which must arise from this circumstance: but it distinctly and very emphatically warns us, to inquire critically into our position as observers—never to be over certain that we have penetrated among the absolute causes, the realities of things. The Universe, however, is always kind; and doubtless the thoughts and schemes of these beings will, with all their error and necessary superstitions, subserve and quicken that slow but stedfast progress—that growing development which appears one main object of the creation of Finite or embodied Intellect.

II. Turn now to the map (Plate XV). It is the reduction of a most valuable work by MM. Baer and Mädler of Berlin, and is vastly more accurate than any map of the Earth we can yet produce. I trust these learned and admirable Germans will not find fault with the use I am making of their labors.* On the face of that map there may be seen a number of comparatively dark, flat, and un-troubled spots, visible in general to the naked eye, and which were at first thought to be *seas*, whence their present names. Not a drop of water however, or of any fluid akin to it, is now in the Moon; for when the line of light in the crescent luminary passes through these so-called seas, its edge, instead of following a fine and unbroken course, is quite irregular—proving that those flats are *land*, although comparatively unbroken and undisturbed:—probably they are in some cases the *subsided* parts of the outer shell or bed of that globe. Besides, there are no *clouds;* and as the Moon has a small atmosphere, this alone is decisive; for, otherwise, vapors would float there, and the purity of the disc appear variable. The question whether water *has been* there—whether in the history of that globe, in the course of its growth and evolutions, the epoch of water or of fluidity in general, has not come, or is passed—is of more difficult solution. Sometimes I have thought I could recognise *caves* in the interior of a crater range of mountains, as if water-worn; and also some prostrate rock whose base might thus likewise have been eroded; but the general and most striking integrity of the mountain ranges—those multitudes of walls unbroken by one torrent, and which contrast so strongly with the ruined shapes and debris of original forms now on our planet's surface, incline to the idea that fluidity, with its varied meteorogical effects, has not yet been there—that the Moon has not reached the age of the Earth. Here we must farther invoke the Telescope. STRUVE's new grand achromatic could throw much light on points so delicate; and something may also be expected from our best reflectors.—As already hinted, our satellite has an atmosphere, although a very small one. It was beautifully seen, under the most delicate of circumstances, during the annular eclipse of May, 1836, when immediately before the completion of the ring—just before the rims of the two bodies osculated, the light of the Sun shot through the Moon's atmosphere, mollified into lovely twilight.

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* The original map is three feet in diameter, and ought to be generally known in this country. It is the only authentic or valuable work of the kind in existence, and its astonishingly small price should give it a wide sale. I wish it were in the cabinet of every *geologist*,—it would prevent a few crude theories.

III. The profile of the Moon is remarkably characterized by inequalities like our mountain ranges; this, indeed, is its most striking feature. It was noticed even by Galileo, whose very moderate telescope shewed the convex edge of the crescent luminary studded with detached spots of light like stars; just as Mont Blanc on a clear evening has its peak brilliantly illumined long after the sun has set to the low country at its base, and when a dark space intervenes between the mountain and the enlightened hemisphere of the Earth. An inquiry of this kind was sure to attract attention; and, accordingly, it has been sedulously cultivated. The first complete investigation of the localities, shapes, and altitudes of the lunar mountains, was performed by Schroeter of Lilienthal; but his labors are now superseded by the more accurate and much more complete survey of Baer and Mädler. M. Lohrmann of Dresden recently undertook the task of producing a map of grand dimensions (twenty-five sheets), but only four parts have hitherto appeared. Availing myself of the elaborate descriptions of all these observers, I proceed to explain the very singular aspects of the mountainous districts of our attendant.

1. There are a great number of perfectly isolated conical peaks or sugar-loaf mountains, springing out of the plains, and unconnected with any ridge or group whatever. Of these, Pico, a clear shining rock, perfectly conical, and much steeper than the famous rock of the Mauritius, is perhaps the most noticeable. It is about half as high as Mont Blanc, and attains this great elevation at once, rising abruptly from the plain. In the middle of craters or cir-

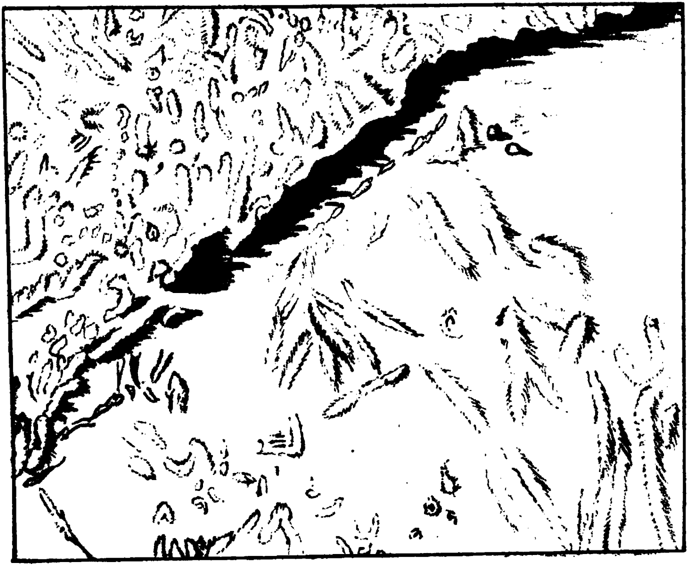
cular formations (which I shall immediately describe) these rocks are often found. They are not unlike such phonolisic cones as the Puy de Griou in Cantal.

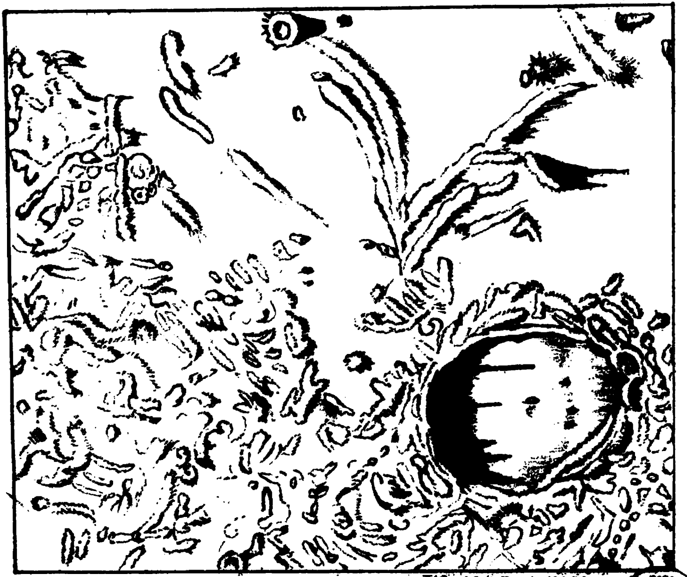
2. Mountains in groups, chains, or ridges, are by no means wanting in the Moon. It has several very grand manifestations of this formation. That chain on its rim, of which Leibnitz and Doerfel are the chief visible peaks (probably twenty or twenty-five thousand feet high), is certainly a portion of a vast mass; and on parts of the luminary more directly presented to us, we have a few examples scarcely less imposing. The APENNINES are perhaps the chief of these (No. 1 on the map), of which a partial and limited sketch is given in Plate XVI., as seen in a certain phase, casting their long shadows over the flats of the *Mare Imbrium*. These mountains constitute a noble highland, not surpassed by any of the ranges on earth. Most precipitous on the side of the plain country, and gradually sloping off through thousands of peaks and minor ridges on the opposite declivity, they strongly remind one of the gigantic plateau of the Himalaya. Some of their cliffs, measured from the *Mare Imbrium*, reach the stupendous height of from eighteen to twenty thousand feet. Similar highlands, although of inferior extent and altitude, are found elsewhere, such as Caucasus. It is extremely singular that the conformation of these masses is uniformly in agreement with what seems a *law* among our terrestrial ranges, viz., they are steep, almost precipitous on one side, and their other is a long slope.

3. But neither isolated peaks nor ranges, are the chief features of lunar mountain scenery. The main type is essentially *circular* or crateriform. Even those large flats, especially the MARE CRISIUM (No. 2 on the map) have something of the round form; and the smaller craters occupy nearly two-fifths of the Moon's visible surface. These

THE APPENINES.

Pl. XVI.



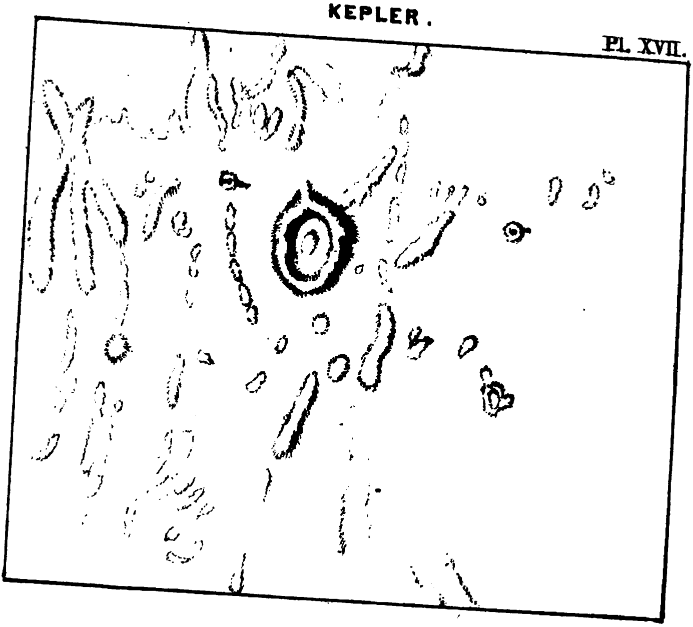


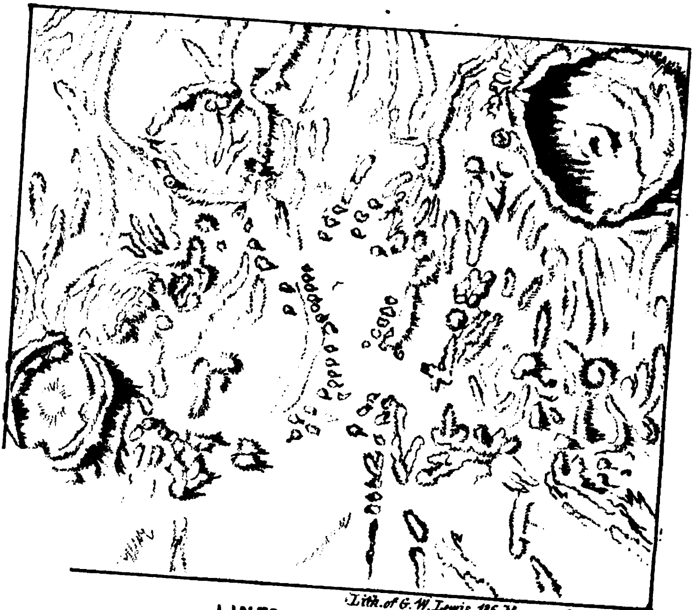
Lith. of G. W. Lewis 186 Nassau St. N.Y.

PLATO &C.

Pl. XVII.

KEPLER.





Lith. of G. W. Lewis 136 Nassau St. N. Y.

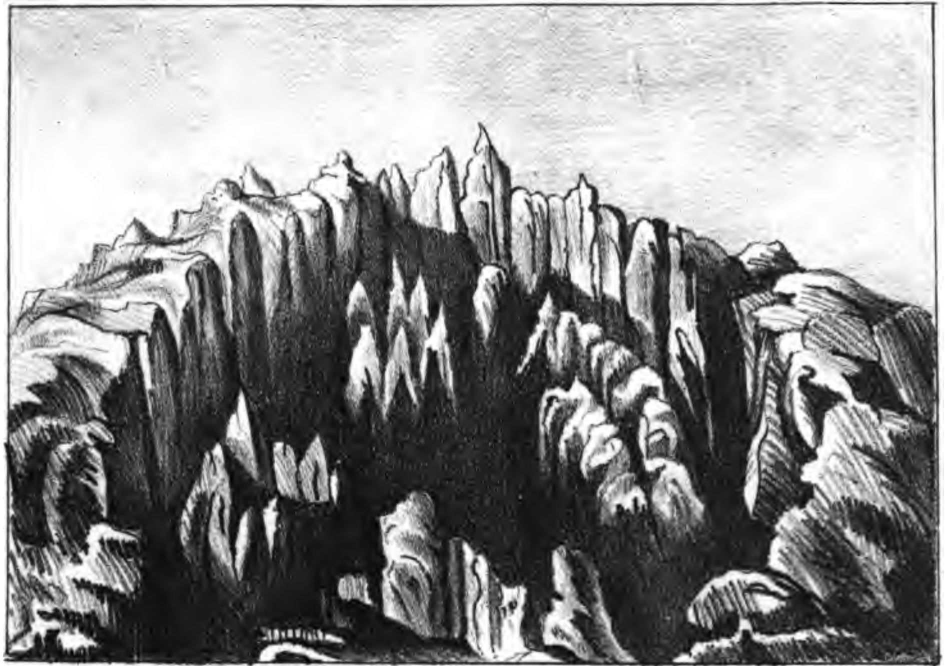
LINES OF CRATERS.

very peculiar circular formations are classed by late selenographists into three orders, viz. *walled plains*, whose diameter varies from one hundred and twenty to forty or fifty miles; below which are *ring mountains*, whose diameter descends to ten miles; and all of inferior magnitude are termed *craters* and *pits*. The relations of these craters to the external part of the Moon's surface, are very various. Sometimes they lie amidst general disturbances, and are surrounded by masses of independent mountains; such, for instance, is PLATO (No. 3 on the map), figured at large in the lower part of Plate XVI.; at other times, as in the case of COPERNICUS (map No. 4)—the noblest of all the perfect craters—connected and manifestly subservient ridges and ranges of peaks rise on their outer declivity; and in some places, as in KEPLER (map No. 5), Plate XVII., their circular ridge rises instantaneously out of a clear district, otherwise not perceptibly affected by the convulsion which gave them birth. Farther, the interference of craters with each other, often materially influences the general conformation of the territory in which they are. In places where they are most crowded, they often interfere with, and inosculate each other—now pressing each other's walls into a hexagonal shape (like a honeycomb), and at other times breaking down the intermediate walls, so that most irregular ranges of mountains ensue, but which have manifestly arisen from the mere proximity of distinct and limited centres of disturbance. Geologists have certainly remarked how nicely these facts interweave with many of De Beaumont's special theories concerning the structure of Auvergne. . The constitution of craters is at once varied, and strictly uniform. On the steep interior declivities of the walls which surround them—walls all serrated on the tops, although the fractures are by no means deep—terraces are sometimes seen going round the whole ring, not unlike the terraces of Glenroy; at other times, as in TYCHO (map No. 6), ranges of concentric mountains encircle the inner foot of the wall, leaving intermediate valleys; again, we have a few ridges of low mountains stretching through the circle contained by the wall, but oftener conical peaks start up, isolated like the Puy de Griou, and very frequently small craters having on an inferior scale every attribute of the large one: the grand essential character, however—that prevailing over all varieties—being this, *the internal depth of the crater is much lower than the general surface of the Moon.* Sometimes, indeed, there is no perceptible outer edge or lip whatever, in which case the crater is called a pit; but, generally, the bounding ridge is from one-half to one-third deeper on its interior than on its exterior edge; and while the exterior declination or slope towards the general lunar surface is gentle and frequently prolonged, the crater is for the most part very precipitous within. The subjoined fancy sketch (Plate XVIII.) exhibits something of the contour of these strange formations; but to comprehend them thoroughly, one must have been among the wildest places of the earth—among those granitic solitudes where no bird is seen, nor heard the cry of the most solitary winged creature, scarcely even an insect's hum; but only the casual hiss of the snake, and the hurried and disturbed creeping of a beetle announce that life exists!

4. Through these various and most strange mountain forms, can relation or law be traced? I venture two guesses—First; it is remarked by Mädler, that chains of lunar mountains sometimes assume a circular arrangement, so that it is hardly possible to tell the difference between true craters, and a large circular chain of separate peaks. This, however, occurs only when we extend the name *crater* to formations of immense comparative diameter; and in such cases, *the circular ring is often studded with*

A LUNAR CRATER.

Pl. XVIII



Lith. of G. W. Lewis 136 Nassau St. N. Y.

Zahara, a golden Savannah in the new world, or a field of luxuriant and freshening Fern. As is known also to ordinary observers, our Luminary shines with most various *intensities*. From Grimaldi (8) to Aristarchus (9), the transition is very great. This brilliancy belongs in part at least to a proper or inherent power of shining in these spots; and the native brightness of the spot Aristarchus, appears to have caused several observers fancy they saw volcanoes blazing in that region. But perhaps the most remarkable circumstance connected with this variety in the Moon's shining power is those *rays* issuing chiefly from craters, and extending over a large space. Kepler (Plate XVII.,) is a fine instance of this; but the best exemplification is Tycho,—unfortunately too large and various to be sketched within a small space. These singular streamers flow over heights and hollows, and never spread out when crossing a valley, so that they cannot be *lava*, or any fluid stream, as frequently supposed. It is clear, however, that they are most closely connected with the elevation of craters, inasmuch as a crater is always their centre: and they thus point to some physical peculiarity regarding the upheaving or crater-forming cause, which is yet wholly unknown. They rank among those numerous points regarding the constitution of the solar system, whose elucidation is demanded of future time.

Closing this sketch of our companion orbs, and anxiously seeking indications of law, amid the varieties which have been disclosed, the attention is arrested by a few general considerations partly definite, partly belonging to the field of pure speculation.

I. Amid these singular varieties, one fact or feature seems so uniform, or at least so general, that the idea of its being a catholic or cosmical feature can hardly be evaded: I mean the presence of an UPHEAVING CAUSE—that grand energy which has elevated our own ranges of mountains. In the Moon especially, in Mercury and Venus, elevations of imposing magnitude unquestionably exist; and, if I am right in my conjecture regarding the origin of the divisions in Saturn's ring, that singular object will eventually offer emphatic illustration of the presence of a similar energy in these remote regions, as well as of *its mode of action*. That elevations have not been seen elsewhere, is proof only of the inadequacy even of our most powerful telescopes. Very probably they also vary the profile, and adorn the landscapes of Jupiter and Mars: but assuredly, enough is already known to demand the extension of our views regarding this wide-spread energy; and to enforce it as a prime geological canon, that no absolute theory be formed of it, with mere reference to the *mannerism* of its existing development upon the Earth.—Remember always that an ant-hill is not the Universe.

II. What is the cosmical meaning or significance of the VARIETIES we have surveyed? Have these globes continued as they are from their birth? Are they changeless, destitute of an inherent faculty of progress, so that the state and form in which we see them is a fixed and abiding one, coeval with their origin, and enduring as their existence? The character of our Earth altogether repudiates this idea. Our world has gone through a mighty and well nigh inscrutable progress, through evolutions stretching along eternities, whose "records are written by the finger of God himself, upon the foundations of the everlasting hills."* It is not probable that those changes will ever be fully scanned: but we know their *reality*, or—*that long progress is essential to our planet's destiny*:—and surely *it* is not *alone* amid the planetary scheme—not alone does it undergo the apparently necessary fate of all beings subject to the empire of TIME and SPACE. Again, granting that every planet has also a life of its own—an interior and self-comprehended principle, by which it is led through mighty developments, the question recurs, whether there is unity or connection among these principles—whether the orbs proceed and pass into new forms, according to similar or related laws—whether, in short the system has one central governing principle, a common life running through the whole, explaining its contrarieties, warming and animating them all, as man's life circulates with his blood? To a question so bold, we cannot here give an answer. Other objects must first be surveyed, especially the *seat* of that power, which, if it exists, is necessarily the SUN.

III. But is LIFE in all these planets? Through all possible schemes, through all conditions of a Globe's evolving organization, is what we call LIFE an inseparable or essential concomitant? Life, visible or invisible—*i. e.* the sentient and intelligent principle—nay even, *progressive* life, a growing and evolving Reason—is doubtless an essential element of the Universe; perhaps the very highest development of any imaginable energy; such Life may be diffused without limit, may assume forms and be connected with *bodies* or centres, of which man has obtained hitherto only the most confined idea: but to the fulfilling and realizing of this aim, is it necessary that small, sentient, self-contained organisms—worshipping, with few dissents, their peculiar IDOLS of the *tribe*, *den*, *forum*, and *theatre*—shall move over the surface of each planet? Beautiful the carpeting which covers vast portions of the Earth, a carpeting on which sorrow often treads, but chiefly joy—now bounding in youth, now placid in manhood, and meditative in age—but *that* is not universal! I reflect on history—on the fact that such life seems among the incidents, the *befalling things* of our Globe's mysterious destiny; and my mind recurs to solitudes—to its still existing deserts, which even the patient Camel does not enter without a shudder; to valleys with giant sides, where the unsightly Cretin, and the frequent glare of Idiocy, speak of Formations inhospitable to man. Sovereign BLANC! Neither is thy bare forehead, which not even a lichen has ever stained, an outcast from the great scheme of things—uncomprehended, unwarmed by the World's indwelling Soul!

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* Buckland.

CHAPTER VII.

CONSTITUTION OF THE SUN.

Now are we in the presence of our central and controlling ORB.

In ancient times the SUN was naturally supposed a great globe of fire. The first revelation of peculiarities in his constitution, we owe to Galileo, whose discovery of the *spots* has already been referred to, as well as his important deduction of the Sun's rotation and its period. The question remained however, *what is the nature of the spots?*—the first approximation to the solution of which I believe was, that they are dark souls of unrighteous angels and men weltering on that sea of fire! The second approximation—belonging to a different epoch—represented them as ashes or scoriæ, the refuse of the burnt fuel which sustained the mighty solar conflagration: and while this latter continued in vogue, a light was thrown upon the subject which even now will be received by many as a marvel, and which I have a pious pleasure in explaining, as it came from my noted predecessor in the Chair I occupy. In 1773, Dr. ALEXANDER WILSON sent a paper to the Royal Society of London, which wholly altered men's views of the constitution of the Sun: and his discovery arose from this—he was the first who, with requisite sagacity, *had made a study of the aspects of a solar spot.* In narrating this most capital discovery, I cannot do better than reproduce Dr. Wilson's plate and language. He writes with the simplicity of genius.

After referring to the theories of Hevelius he says, "The many strange and variable circumstances of the spots, which were discoverable from a minute observation, still remained unaccountable; and we often find astronomers at a loss, in framing any hypothesis which could fully satisfy the mind concerning them. In process of time, they began to withdraw their attention from a subject which remained so dark and perplexing, and, for many years, all researches of this sort have been, in a great measure, laid aside. Chance, or a happy concurrence of circumstances, hath sometimes effected more, than could have been expected from the most promising measures: a remark which, it is hoped, will, in some degree, be found justified in the sequel of this paper. The observations upon the solar spots, which I now proceed to relate, appear to be totally different from any hitherto to be found, and such as seem to open a new and curious field of speculation into the whole of this subject. Astronomers will remember, that a spot of an extraordinaay size appeared upon the Sun in the month of November 1769. The first notice I had of it, was by a letter from a friend at London, but the weather continued dark and cloudy for some days after; at length, on the 22d day, I had a view of the Sun through an excellent Gregorian telescope, of 26 inch focus, which magnified 112 times.* I then beheld the spot, which at that time was not far from the

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* This telescope still exists.

Sun's western limb, and below his equatorial diameter. The atmosphere being now very clear, and free from all tremor and undulation, it was pleasant to see the nucleus of the spot, and the shady zone or umbra which surrounded it, so very distinct.* It being afternoon when I first got sight of it, I had not an opportunity of observing it long that day. Next day being the 23d, I had the curiosity of seeing it again, and so repaired to my telescope, in order to examine if any alterations in the size and figure had taken place since last observation. The air was still favorable, and I again saw the spot, it having its nucleus and umbra very sharply defined. I now found, however, a remarkable change; for the umbra, which before was equally broad all round the nucleus, appeared much contracted *on that part which lay towards the centre of the disc*, whilst the other parts of it remained nearly of their former dimensions. This change of the umbra seemed somewhat extraordinary, as it was the very reverse of what I expected from the motion of the spot towards the limb. The next day at 10 o'clock, I had another observation, and discovered changes, which were still more unexpected. The distance of the spot from the limb was now about 24″. By this time the contracted side of the umbra above mentioned had entirely vanished; and the figure of the nucleus was now remarkably changed from what it had been the preceding day. This alteration of the figure appeared evidently to have taken place upon that side which had now lost the umbra, the breadth of the nucleus being thereby more suddenly impaired than

it ought to have been by the motion of the spot across the disc. Fig. 1, 2, (Plate XIX.) represent the appearance which the spot had on the 23d and 24th days.

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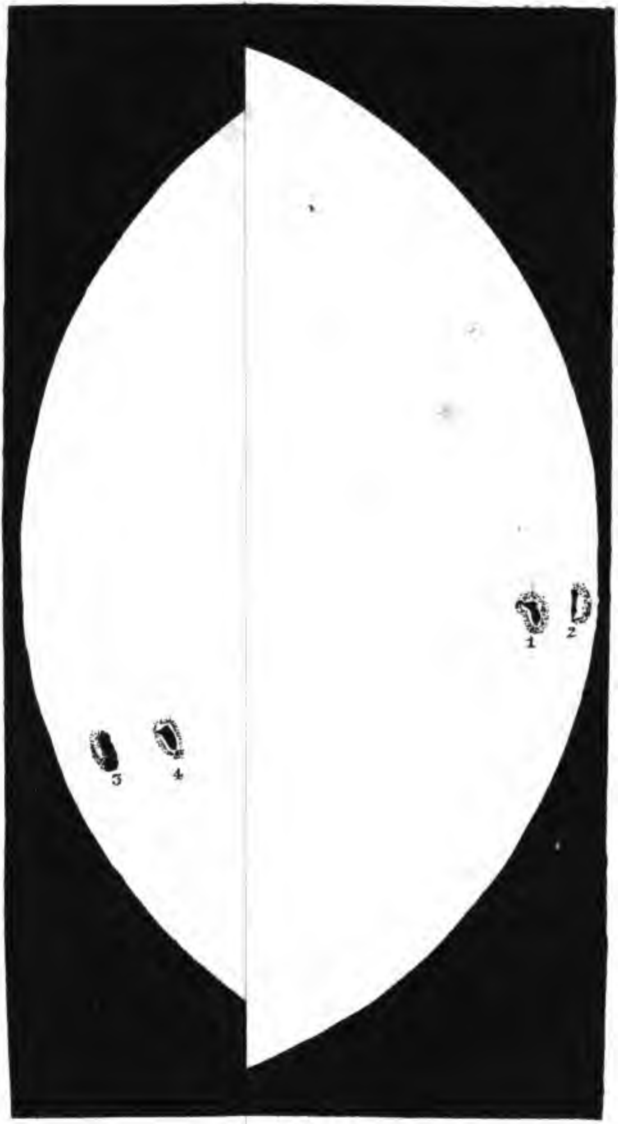
* The form of a solar spot is this,—its centre or nucleus is quite dark. Around that nucleus there is a rim or belt of a brighter shade, but still much darker than the general disc; this is the *umbra*. A considerable number of spots are represented in Plate xx, where the appearance now referred to will invariably be found.

"Regarding these circumstances as new, I began to consider what might be the cause of them. One of two things seemed necessarily to be the case; either that they were owing to some physical alteration or wasting of the spot, and of that part of it where the deficiency of the umbra is observed; or else, that they were owing to the nearer approach of the spot to the limb, by the Sun's rotation on his axis. The last of these two ideas had no sooner struck me, than I began to suspect that the central part or nucleus of this spot, was *beneath the level of the sun's spherical surface;* and that the shady zone, or umbra which surrounded it, might be nothing else but the *shelving sides of the luminous matter of the Sun*, reaching from its surface, in every direction, down to the nucleus: for, upon this supposed position, I perceived that a just account could be given of the changes of the umbra and of the figure of the nucleus above described.

"The opinion, therefore, which I ventured to form from what I had seen this day, was, *that this spot might* probably *be a vast* EXCAVATION *in this luminous matter of the sun;* the nucleus, commonly so called, being the bottom, and the umbra the shelving sides of the excavation: and, moreover, that the umbra, next the centre of the disc, although out of my view, did still however exist, and was rendered invisible by its present position only; and further, that the sudden alterations, now discernible in the figure of the nucleus, were occasioned by some part of it also being hid by the interposition of the edge of the excavation between the nucleus and the eye. These views, which now presented themselves, I remember to have communicated that afternoon to my son, when I told him that, if they

Pl. XIX.



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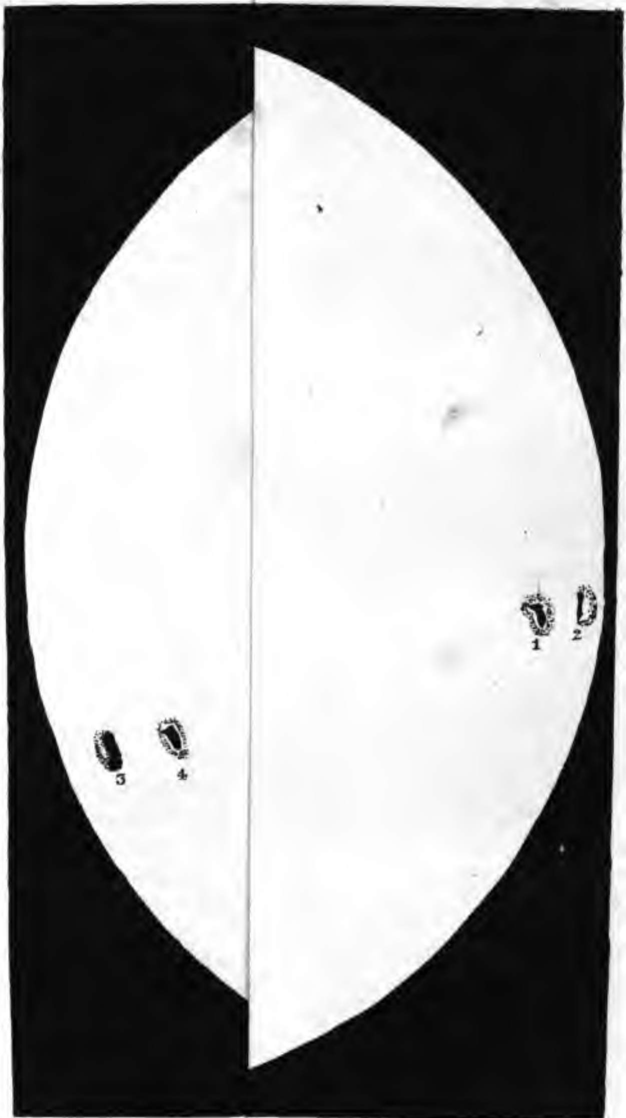

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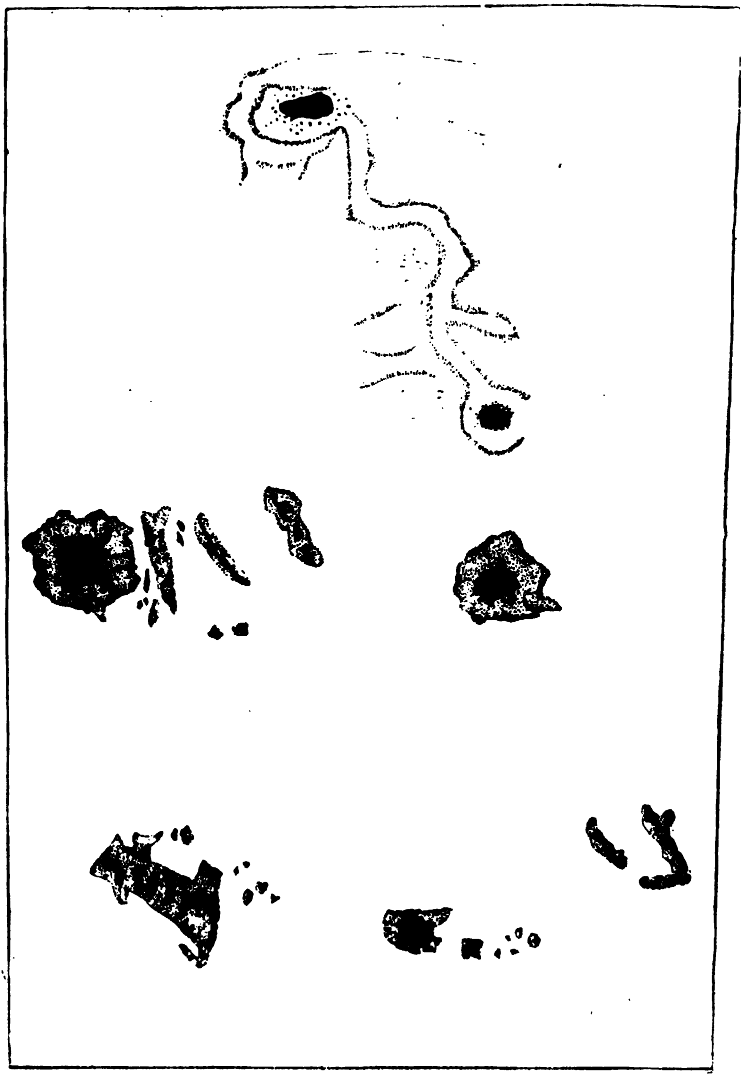
were well founded, there would be room to verify them if the spot should again return upon the opposite side of the disc. I was, however, uncertain, if it would last so long upon the Sun's body as to be again visible after the time of half a revolution, a circumstance which I wished to take place, as I was aware that my present observations might justly be deemed insufficient for establishing so singular an opinion concerning the nature of this spot; and that, notwithstanding all which I had seen, we might still imagine that these changes were produced by certain physical alterations of the spot itself.

"These considerations made me attentively wait its return. At last, on December 11th, I again discovered it on the opposite side of the disc, it having by that time advanced a little way from the eastern limb, being distant from it 1′ 30″. And now I could only perceive three sides of the umbra, namely the upper and under sides, and that towards the limb, which was the side that formerly had vanished. The side towards the centre of the disc was not as yet visible; but I concluded, upon the same grounds as formerly, that it was hid from my sight by its averted position only, and that after the spot had advanced a little further it would make its appearance. Accordingly, the next day, being December 12th, at ten o'clock, it came into view, and I saw it distinctly, though narrower than the other sides. After this, my observations were interrupted by unfavorable weather till the 17th, when the spot had passed the centre of the disc, the umbra now appearing to surround the nucleus equally. Figs. 3, 4, and 5 represent the spot, as it appeared on December 11th, 12th, and 17th, when it came upon the disc for the second time. All the foregoing appearances, when taken together and duly considered, seem to prove in the most convincing manner, field opened by these splendid discoveries. They started altogether a new idea concerning the structure of the Universe; and it sustained the repute of the Danish kings, that one of them struck a tasteful medal in gold in commemoration of the achievement. Of old—even after the reformation of Copernicus—the Sun continued the subservient body of the system, the servant and minister of all; but now he has started into independent existence, himself a grand organization, structure and plan in his vast body, and only ministering to his subservient orbs, or binding them by close relations to himself in virtue of one quality—the effulgence of his atmosphere, which is yet far from limiting his functions, or characterizing the manner of his being! Dr. Wilson was greatly honored by the Danish kings, but this highest honor awaited him—Sir WILLIAM HERSCHEL, who led all other observers, and stamped on Astronomy its modern epoch, followed here; and, with his large telescope, perfected the efforts of his friend.

Referring for details to Herschel's paper in the Transactions of 1801, I shall be satisfied with a brief statement of the positive results of his laborious investigations. The fluidity or gaseous character of the Sun's atmosphere was fully established by them. It is altogether in a state of commotion or rather of instability. Agitated apparently by strong causes, it often accumulates into masses like waves, whose summits, now round, now in ridges, constitute bright places or *faculæ*, which, when seen through an adequate telescope, have the aspect of a broken mackarel sky. Under this bright atmosphere lies another, less luminous—a mass or stratum of clouds like what floats around our own planet, illumined strongly by the superior stratum, and throwing back a reflection of that light. This

SPOTS OF THE SUN. **Pl. XX.**



bed or stratum constitutes the *umbra* or darkish *hem* of the spot; and the nucleus itself is, as my distinguished predecessor conjectured, a vista of the dense body or real substance of the Sun. The thickness or depth of the two atmospheres is at least several thousand miles. Connected with the probable origin of the spots there is one remarkable phenomenon: a *facula* or bright ridge *always surrounds a spot*, as if the light atmosphere were accumulated there, or heaped up; *the opening in it having been blown out from below*, as Dr. Wilson conceived, *by some explosive or deflagrating energy*. Here again, then, we meet with an UPHEAVING POWER even in the SUN; a Power which surely is COSMICAL. Observe also its character. The spots, as represented in Plate XX., shew decisively that they result from local disturbances, that they do not arise from any general or extended action within the Sun's body, but merely from deflagrating or explosive forces, *whose seat is comparatively superficial*. In one case alone (Fig. 1.) do they appear to have had an extended linear efficiency; but this single instance shows, as in the Moon, that they may take on such forms without being *central forces*, or emanating from the centre of the Sun's mass. Abiding faithfully by the belief in an unconfined and unlimited analogy and relationship amid things, I have a firm impression that these spots are not diverse from the craters of the Moon; and that they will be found eminently illustrative of the general nature of the upheaving cause.

The nature of the light-giving atmosphere of the Sun is as mysterious as when Dr. Wilson wrote the sentence which closes our extract from his paper. Arising from some electric action direct or mediate, it may be akin to our beautiful Auroras, which, indeed, are no *peculiar* phenomena, inasmuch as similar flames occasionally illume the dark hemisphere of Venus; and the obscure part of the Moon has also been visited by coruscations said to appear like lightning. The question cannot fail to suggest itself here—whether this light-producing power may depend in *degree*, on the probably ever-changing electric state of a growing globe, whether the Sun is now as he was and will ever be, or only in *one state or epoch of his efficacy* as the radiant source of light and heat? It seems to me most worthy of consideration, whether those puzzling phenomena, indicative of an altered heat in our Earth, may not pertain in part to this source—to the onward progress of our heat-giver through the destiny to which law foreordained him? The changes referred to stretched over epochs in which man was not present, and when, of course, their progress could not be marked; but even now, due attention is not paid to the momentous subject; for the delicate measurement of the Sun's direct strength is of greatly more consequence than that temperature which arises for the most part from a mere terrestrial meteorology. The farther Heavens, however, come here in aid, and supply this gap in our knowledge—appearing to substantiate the possibility, if not the reality, of such changes. The new star in Cassiopeia seen by Tycho, for instance, indicated some great change in the light and heat of an orb, far more probably than a mere orbitual motion. *That star never moved from its place;* and, during its course from extreme brilliancy to apparent extinction, the *color* of its light altered—*passing through the hues of a dying conflagration.*[*] Can ought of this be seen in the

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[*] These bodies must not be confounded with *variable stars*—stars whose light increases and decreases in definite periods. The regularity of this period points out *rotation on an axis* as the most probable cause of the phenomenon. Indeed, this phenomenon or characteristic seems in all respeets cosmical or univcrsal.

Southern star—one of Sir John Herschel's spoils—which is gradually clothing itself with an extreme brilliancy?* Many other stars have altered slowly in magnitude, also preserving rigorous invariability of place; and some, as SIRIUS, have changed color,—this star having turned from the fiery dog-star of old times, red and fiery as MARS, into the brilliantly white orb now adorning our skies. Is it not likely then, that the intrinsic energies to whose development these phenomena must be owing, act also in our Sun,—that, in short, he also may pass through phases, filling up myriads of centuries—once it may be shining on Uranus with a lustre as burning as that which now dazzles Mercury? How vast are the effects involved in such a change! The rays of the Sun are not merely light-giving; for combined with these, in the same beam or pencil, there are rays whose function is heat-giving, and others equally distinct, which are productive of chimical influences. Now, in the probable march of our Luminary, how great a variety in the relations of these three systems of rays may be involved; and, of course, what diversities in his action on his dependents! Imagination clinging to such conjectures, passes to the august conception of this Master of surrounding worlds, this

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[*] The following is Sir John's account of it. "The star η Argus has always hitherto been regarded as a star of the second magnitude. During former years I have always considered it so, and never had reason to suppose it variable. In November 1837, I saw it as usual. Judge of my surprise to find on the 16th December, that it had suddenly become a star of the first magnitude, and almost equal to Rigel. It continued to increase. Rigil is now not to be compared with it; it exceeds Arcturus, and is very nearly equal to α Centauri, being at the moment I write the fourth star in the Heavens in order of brightness." After the authentication of a phenomenon like this, who shall venture to eliminate *astronomical* influences from among the agents of *geological* change?

it ought to have been by the motion of the spot across the disc. Fig. 1, 2, (Plate XIX.) represent the appearance which the spot had on the 23d and 24th days.

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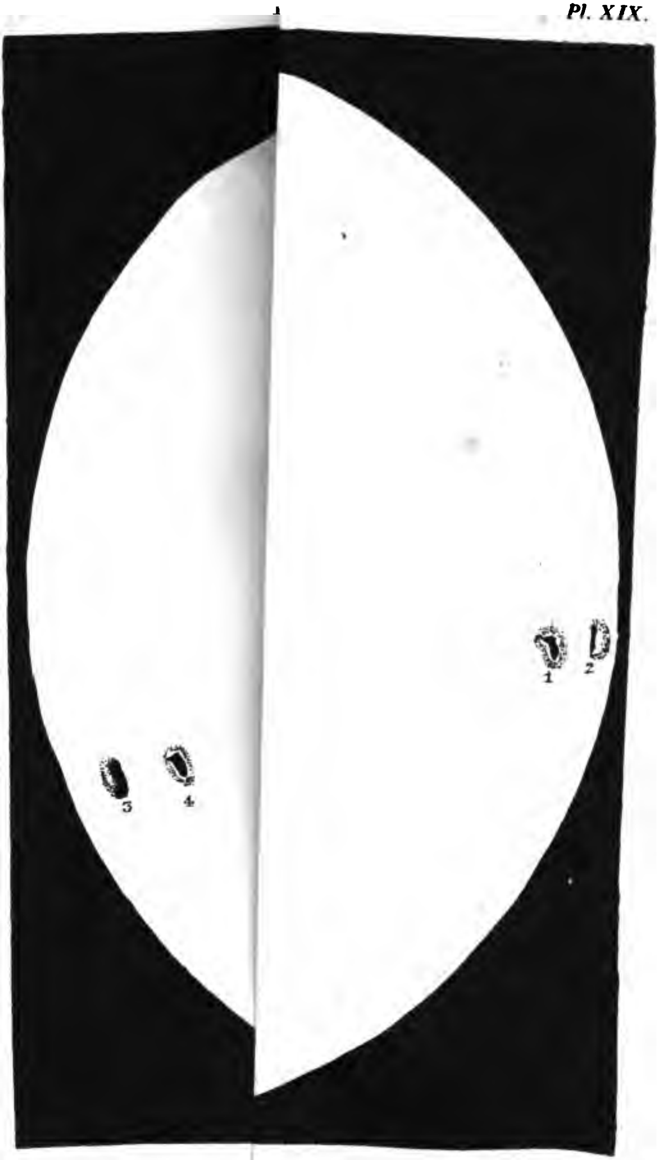
Pl. XIX.



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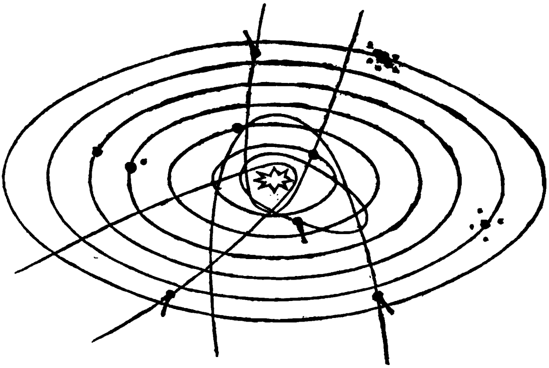
hair"—causing pestilence—predicting wars—threatening the Earth, now with fire, now with flood,—these harmless wanderers have been especially cherished by the superstitious principle in man; nor was it until very recent years that they exchanged their fancied demoniacal mission into that of ambassadors from the farthest spaces of our firmament, where their home and relations are found. Plate XXI. gives a view of the two most remarkable bodies of this kind which have become denizens of our systems, the upper figure being Halley's comet, as seen by Mr. Cooper at Markree with his great achromatic; and the lower the celebrated comet of Encke, which moves round the Sun in little more than three years. I have selected these two for representation, partly on account of the intrinsic interest of the objects, but chiefly because the different forms of their tail or chevelure exhibit the varieties assumed by this concomitant of these bodies. In Halley's it is elongated, and in Encke's rounded and shortened, constituting a figure approaching to a regular oval. In all cases, this tail is *hollow*, as if it consisted of particles driven away from the nucleus by the resistance of an ether or substance through which the comets move. It has been known to stretch over forty millions of miles.

Refraining from useless speculations on the physical nature of comets—which is still utterly dark, although Bessel and Arago have lately shown the road to definite knowledge; I would request attention to the vast number of these bodies and the peculiarity of their relations with our system. Three alone have been recognized as denizens of it; one Halley's, revolving in its path in about 76 years; the second, Biela's, revolving in 6¾ years; and the third, Encke's, completing its course, as already said, in 3¼ years. The multitudes which visit us—multitudes beyond numbering—go into regions wholly untrackwere well founded, there would be room to verify them if the spot should again return upon the opposite side of the disc. I was, however, uncertain, if it would last so long upon the Sun's body as to be again visible after the time of half a revolution, a circumstance which I wished to take place, as I was aware that my present observations might justly be deemed insufficient for establishing so singular an opinion concerning the nature of this spot; and that, notwithstanding all which I had seen, we might still imagine that these changes were produced by certain physical alterations of the spot itself.

"These considerations made me attentively wait its return. At last, on December 11th, I again discovered it on the opposite side of the disc, it having by that time advanced a little way from the eastern limb, being distant from it 1′ 30″. And now I could only perceive three sides of the umbra, namely the upper and under sides, and that towards the limb, which was the side that formerly had vanished. The side towards the centre of the disc was not as yet visible; but I concluded, upon the same grounds as formerly, that it was hid from my sight by its averted position only, and that after the spot had advanced a little further it would make its appearance. Accordingly, the next day, being December 12th, at ten o'clock, it came into view, and I saw it distinctly, though narrower than the other sides. After this, my observations were interrupted by unfavorable weather till the 17th, when the spot had passed the centre of the disc, the umbra now appearing to surround the nucleus equally. Figs. 3, 4, and 5 represent the spot, as it appeared on December 11th, 12th, and 17th, when it came upon the disc for the second time. All the foregoing appearances, when taken together and duly considered, seem to prove in the most convincing manner,

ed; and although many of these may also be denizens, that is, although they may have re-entering and bounded orbits, there is reason to imagine that the greater number visit us but once, and then fly off almost in straight lines until they approach the influence of other orbs. Can it be possible, as supposed, that these bodies are wholly *monstra?* That they have no proper abode, or harmonious relationship in creation? This is inconceivable, for assuredly Creation is one grand Unity; but wherever the Home of these wanderers, it is clearly not in our planetary system, from which they go, and to which they come, in fashions wholly irreconcilable with all laws which the planets obey. In the supplement to part first, I minutely specified the essential characteristics of all planetary motions; to these, the comets own no allegiance; they are found in all quarters of the heavens, quite irrespective of the Zone of the planets; they move in most elongated ellipses—often probably in parabolas, or ellipses infinitely extended; and they dart towards us in all directions, now rolling like the planets and again with a contrary or retrograde motion. Observe in the woodcut, their most devi-



ous courses! Surely they belong to another state of things; surely they belong, however mysteriously, to the far heavens; perhaps they are an agency binding our home system, with external phenomena; linking our small and compact scheme to other modes of Being; and promising to the sedulous inquirer more conquests over the Unknown.

With this dim and faint vista of Infinity, I close our survey of the physical characters of our System.

PART III.

GLIMPSES OF THE UNITY OF THINGS.

INTRODUCTION.

I am now engaged in unfolding a Law, expressing and comprising the Order of the largest range of material phenomena that has ever yet been thoroughly explored,—which not only combines into one simple announcement the three principles of celestial motion elaborated by Kepler, but also throws a flood of light on the relationships of the physical varieties we have just discussed;—an order enclosing, within a high and impregnable wall, the vastest of man's conquests over the Unknown; but withal which is as simple as sublime things generally are, so that to be impressively exposed it has only to be exhibited as it is. Beautifully do these Stars which so puzzled Purbach, glide through the Heavens which are their own, calmly moving through predestined courses, never found where unexpected, or where the Great Spirit has not arranged for their welcome! . Orbs, familiar, and yet wonderful! Slowly they roll onward, calling the Earth their Brother, and filling with a living joy all our Sun's domain: far into Space too they send forth their voices, claiming to be acknowledged by the Order which dwells there, to belong to it through Descent, and still to constitute an indestructible part of that universal Life which has been subjected to Time.

CHAPTER VIII.

GRAVITATION.

It is essential to a due appreciation of the principle about to be exposed, that we apprehend the distinct nature of a physical *cause* and a physical *law*. The physical or immediate *cause* of any event, is merely that other event without which as a precedent, the other never occurs. We say that one event *causes* or brings about another, not because aught is visible—any peculiar virtue—in the first event, which *necessitates* the second; but because it is so arranged in the economy of the known Universe, that when the first happens the second always follows it. And if we find events so ordered, that in a long series of changes they succeed each other after a certain recognizable plan, we term that observed plan, the *law* of these events. The name or word LAW does not thus involve the idea of any controlling power; it is the mere result of an observed succession—the mode by which we thread together in our minds, the different events which befal; and if the slightest element involving control is properly connected with it, it can only be in reference to the relation of such succession to spiritual or mental phenomena, and ultimately as it represents that IDEA in the Almighty Mind according to which the order in question was arranged.

The doctrine now exposed was not *practically* embodied in physical philosophy, until Kepler had delivered those three Laws, which, it must be recollected, were pure and immediate deductions from the stores of Uraniburg. It seems to have occurred, simultaneously, about the times of which I write, to many persons, that the discoveries of this remarkable astronomer might somehow be compressed or consolidated into ONE GRAND PRINCIPLE, expressive of the same order, and probably capable of a still wider grasp. KEPLER himself grazed the result; and interesting approximations are owing to Huygens, Hooke, and Christopher Wren: but no mathematician who had yet appeared save one, had power to bring out and define the secret, thus as it were looming in all men's sight. That single person was ISAAC NEWTON—a man upon whom no eulogy need be pronounced, for his name is almost as an household word—the immortal Englishman is one of the world's best known citizens.

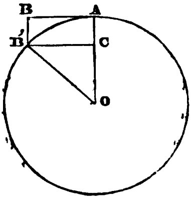
NEWTON entered on the consideration of the motions of the Heavens by distinctly defining a new dynamical system, or mode of considering *forces*, which had been growing into notice. The first fundamental fact or hypothesis (?) of that system is—*that every body on receiving an impulse, or on being acted on by one impelling force, would move onward forever in a straight line, in the direction of the force which impelled it.* Now, we find the planets moving, not in straight lines, but in ellipses or ovals; so that some other force, some *deflecting power*, must act upon them—constantly drawing them out of their natural rectilinear paths; and the question was, what is this second and constantly acting deflecting power? Instantly that the problem of the celestial mechanism assumed this shape, it became most distinct and tangible; for it was clear that Kepler' researches contained a key to the mystery to be divined: and contemplating them from the foregoing point of view, Newton readily passed through the following three steps of discovery. *First*, he deduced by a remarkably simple and beautiful process, from Kepler's second law, the one viz. exposed in page 77, that the deflecting force or energy is *directed towards the centre of the Sun;* this truth, indeed, is the significance of that second law. But again, why do the bodies move in *ellipses*—or, what is the significance of Kepler's first law? Profounder mathematics, and the introduction of important novel conceptions in that science, were requisite for the resolution of this part of the inquiry; but Newton was adequate to the task. He found that this attracting force or energy, which constantly draws the planets towards the Sun's centre, and thus deflects them from rectilinear into curved orbits, is *not the same in strength* for any planet at its different distances from the Sun; that it diminishes as the planet recedes, and according to a rate depending upon the *square of the distance.* This technicality will be easily understood. The *square* of a number is that number multiplied by itself; the square of 2 being 4, the square of 3—9, the square of 4—16, &c. Now suppose the Earth at one time *twice* as far from the Sun as at another (which it never is), the attractive force of that luminary would in the former case be *four times* less than in the latter, *i. e.* it would have diminished in proportion to the *square of the distance:* and it is owing to this peculiar rate or mode of the attractive energy's decrease, that the planets move in one of a peculiar family of curves. It must be noticed, however, that this rate only restricts their paths within a certain *family of curves;* for even under its control the planetary motions might have been most varied; the orbs were free to move, for instance, in very elongated and narrow ellipsea, or even in courses assumed by some comets, which apparently have no extreme limit, but pass off into Infinity. There is, therefore, some principle or regulation *within* this law of Newton's, telling why the peculiar curve out of this whole family, chosen by the planets, is an *ellipse*, and why an ellipse so near to a circle?—a principle, however, which, as we shall see at the close of our volume, is profounder and more remote than gravitation itself. . But to resume; A third step in the process of redaction or *compression* still remained. What is the significancy or meaning of Kepler's third law?—that which binds the different planetary motions into a close relationship. Up to this point their orbits were *individuals*—without connection or unity. An attractive power exercised by the Sun over *each* orb had explained *each* orb's path and varying velocities; but still the *comparative strength of the Sun's attraction over the different planets* continued unexplored: for instance, it was not known whether the Sun attracts the *Earth* more or less strongly than he attracts *Jupiter*. Now Kepler's third principle immediately removed all doubt on the subject, and in Newton's hands, unveiled the great truth, that the force of attraction drawing the planets to the Sun's centre is one and the same—that it is not, for instance, in one case an electic attraction and in the other a magnetic, but merely a uniform manifestation of one sovereign power,—*its strength decreasing in intensity, in the case of* EVERY *planet, according to the precise law followed through the orbit and varying distances of* EACH; *i. e.* a planet at *twice* the distance of the Earth from the Sun, is drawn to the Sun by a force *four* times less than that which influences and deflects the Earth. Observe the simplicity with which the law of the motions of the celestial orbs could now be announced; and contrast it with the cycles of Ptolemy!

THESE ORBS ARE DEFLECTED FROM THEIR NATURAL RECTILINEAR PATHS BY A FORCE DRAWING THEM TO THE CENTRE OF THE SUN, WHOSE POWER DIMINISHES AS THE SQUARE OF THE DISTANCE OF THE PLANET FROM THAT LUMINARY INCREASES; such is the simple and final result of the toils of more than twenty centuries! Would that Kepler—the great and pious German—had obtained but one glimpse of this result of the imperishable legacy he received from Uraniburg! Would that he had discerned how all the varieties which so puzzled him, and which he did so much to reduce within order, are resolved, by a fine balancing—the regulated conflict of two tendencies—one, that tendency to motion in a straight line, which of itself would induce the planet to dart off into Space, and the other a fixed, determined, and simple deflecting Law! But doubtless, he has ere this seen far more; and even as he loved when on earth to trace out and embalm the faintest and first elements of thought in the labors of all who preceded him, which might seem to have heralded discovery—so it cannot ever be indifferent to his noble spirit, that by aid of Tycho's storehouse he was himself proximate to the Intellect which unveiled the beauteous simplicity of things.

I would pause in our course of exposition, and revert once more to the nature of LAW. It cannot possibly be overlooked that the principle of gravitation, in so far as we have yet developed it, contains nothing which was not in Kepler's three discoveries; *i. e.*, it is a mere exposition of the existence of an order through the motions of the planetary system. This is especially to be noted; for the name *gravitation* has gotten hold of men's imaginations, as if it were an occult or secret power or principality; something which—besides expressing the facts of the planetary motions—involves the idea of an influence compelling or producing those motions. The misapprehension, however, has not its roots very deep; and remembering that Kepler's laws are simple results of accumulated observation on the order of planetary motions—we cannot now be deceived. Correct notions on this matter are of considerable practical import. How unfounded, for instance, is the apprehension of timid minds, who, when we trace out a long order through events of past time, or carry the influence of law profound into the future, dream that we overlook the Great First Cause, and exclude God from his own glorious Universe! Regarding Law, not as causative but expressive—as the simple indication of mighty arrangements—a gleam into the Finite Mind from that of the Creator—surely the farthest stretch of vision which man can ever achieve, is only a further disclosure of Almighty glory and excellency. With the real philosopher, want of devotion is impossible; and the great but simple Newton, feeling more than some of his followers the bearing of the truths he had revealed, seems in this respect, even in the pride and fame of his immortal discovery, possessed and sometimes overcome by the emotions of a thankful child, bending in reverential gratitude that he had been enabled to look into the ways of the beneficent fashioner and Father of All!

The Law of Gravity was still far from its term. Upon this point, it had only consolidated old ideas; it had simply expressed Kepler's principles in the following brief and compact manner,—the Sun attracts all the planets, and the planets attract their satellites or moons, with an energy whose strength or efficacy diminishes in a certain relation to the distance of the attracted body. But has this attracting force relationships with other than planetary phenomena; is it purely celestial, or has it alliances with classes of other facts, which occur around us? Struck by the tendency of all bodies to fall towards the Earth—which in common language we call their *weight*, and penetrated by that abiding sense of analogy through all nature, which is stamped on the mind of every true philosopher, Newton, retired at the time in his country seat, asked himself, whether this operation or succession of events might not be identical in nature with that obeyed by the Moon, and which retains her in her orbit?

The problem, stupendous though it appear, was quite resolvable; and the process which would conduct to its answer, is by no means hard to be comprehended. For instance, supposing the Earth at O and the Moon at A, if the Earth exerted no attraction over the Moon, she would move in a given period, say in a day, through the rectilinear path AB: but, on the contrary, we find her at



B′, so that the attraction of the Earth has caused her to *fall* through the space BB′ or AC (approximately speaking) in that time; and by this fall, which is quite calculable, we are enabled to say how much the Moon, if not moving in any orbit, would at that distance, approach the Earth in one second of time; in other words, *what is the exact measure of the strength of the Earth's attraction over her, at her present distance.* But we know how far a stone falls in one second, at the Earth's surface; which fixes the strength of attraction at the distance from the

Earth's centre of its own half diameter:—Are these two forces, therefore, one and the same? Do these two quantities or numbers hold to each other the relation expressed by the law of gravity? *i. e.*, is the space through which the Moon falls in one second of time smaller than the quantity through which a stone falls in one second at the Earth's surface, just as much as the *square* of the Moon's distance from the Earth's centre exceeds the *square* of the stone's distance from the same centre? The accurate resolution of the problem, it will be seen, depends on the accuracy of the data,—on the known diameter or size of the Earth, and of the distance of the Moon. When Newton first undertook it, his data were not accurate. The result of course was incongruous with his conjecture; and with the honor of a man who loves truth, he threw his theory aside. Three years after, truer measures of the required quantities were obtained; and he revised his old calculations. It is recorded that towards the close of his work,—when it seemed that the results were coming in accordance with his surmise,—when he felt on the verge of obtaining one of the most important laws ever revealed to man,—when in short he was recognizing that which for ever more would bind the Heavens to the Earth, and constitute himself the first of philosophers—the nerves of the great man quivered, and he could not finish his task. He called in the aid of a friend, pacing his room in tumultuous agitation, while the few last arithmetical operations were being concluded, and perhaps as fearful at the moment lest his conjecture might be true as that it should prove fallacious! It is difficult now to conceive the intensity of Newton's feelings when the result was finally announced to him. By effect of familiarity it has become common; but revert back to the revolution it made in man's knowledge of the universe. No order or connection among events had then been discovered save what lay in Kepler's laws—which, limited as they are, it had required the intellect of the previous world to elaborate; but here was a revelation not merely tracing some farther small analogy, not binding together more closely the character of the planetary orbits, but uniting them in all their majesty, with the simplest of terrestrial phenomena, and demonstrating that over a drop of spray, tossed in an apparently random course through the gulf of a cataract, or across the rocky barriers of a raging ocean, is dominant the same regulating power which retains the great Planets with their Moons in their sweep around the Sun. Knowing how trifling a novelty may agitate the firmest minds, no wonder that Newton was affected by an incontrollable tremor. And it may be that at that moment he perceived not only the extent of those great tidings of which he had become the herald, but also that an entire change had passed over himself—that, instead of the persevering and successful private student, he had become a name which would never die from the minds of men.

How vast and engrossing has the principle of Gravity become! If, as demonstrated, it is that same principle which regulates the fall of a stone, may it not even be Universal? May not every particle of matter attract every other particle, however much apart? May not the Earth, for instance, attract the Sun as well as his enormous mass attracts the Earth, and force motions also on him? Newton hastened to this wonderful generalization; and physical philosophers, such as Cavendish, have sustained his conclusion by most delicate experiments: so that, after the longest toil, we have reached the grand consummation, that the planetary fabric is built like our own terrestrial scheme; and that *every particle of matter attracts* *every other with an efficacy decreasing according to the square of the distance.* Such then, is our nearest view of the secret of the mechanism of things,—such the grand LAW OF GRAVITY.

It is remarkable that Newton, notwithstanding of his possession of this illustrious discovery, and his consciousness that he had based it on demonstration, was not only slow in communicating it to the public, but retained it silently in his repositories, uncommunicated even to his private friends, until, by accident, Dr. Halley drew from him the secret of his riches. The explanation of a reticence so singular holds by several feelings habitual to our countryman. In the first place, and above all things, he loved contemplative repose. Previous to the time referred to, he had published discoveries in other parts of science of vast moment, but which, in consequence of the ill-prepared state of men's minds, had been met with no welcome; and Newton, whose repugnance to wrangling with frivolous and acrid men amounted to a morbid revulsion, might have cherished the idea, that this true System of the World, he would, with other discoveries, bequeath to his fellow-men as a legacy—leaving them the result of his labors after all had terminated. But he possessed, besides, a modesty of intellectual demeanor scarce paralleled in literature or science. He never seems to have placed himself, even in idea, beside his fellows; but always in presence of the vast Universe, and of HIM the maker of it. His mind was therefore stamped with a grave and reverential abasement; he compared his discoveries, not with what had been accomplished before, but with what remained to be done; the law of gravity itself was but as a sound of distant waters, a little gleam from the unknown; telling, however, distinctly of its home—like the shell of the Arabian Maid in Gebir,

Apply its polished lips to your attentive ear,
And it remembers its august abodes,
And murmurs as the Ocean murmured there!

The discovery of that wonderful and far-stretching relationship among material things which is expressed by the word Gravitation,—a relationship and sympathy, more extensive and closer than the boldest imagination had hitherto dared to hope for, could not remain barren or long unfertile of new illustrations of the character of our system. One of its earliest and most striking fruits was a resolution of the nature of the cometary paths. If gravity is universal, these singular bodies, instead of wandering through capricious orbits, must also, under the guidance of the Sun's attraction, move in some one of that family of curves within which all motion under control of gravity appears confined; and accordingly, although multitudes, in obedience to that law, choose that special curve which never re-enters into itself, and therefore, after once visiting us, dart away through the abysses of space, others, as already mentioned, move in long ellipses, and seem at present permanent denizens of our system. While such ideas were stirring Newton's mind, that body seen by Kepler, and lately again visiting our heavens, most opportunely appeared; and the sagacity of HALLEY detected its orbit, measured the duration of its course, and predicted its return. This was indeed a triumph for the intellect of man! And once more has that same power been exercised before our own eyes with most splendid efficiency—for we have followed that hazy thing, itself lighter than the thinnest cloud, through tracks of space where planet never rolled, far beyond the system's confines; we have noted its periods and course, and foretold, within a few days, the time of its return. Gazing on our mysterious visitant, and not without a shade of sadness, well knowing that its large year outspans the period of one of Earth's fleeting generations, and that, when it once more returns, it will tell of the victories of science, not to us, but to those who are fast forgetting us, the thought clutches by the heart, that man must be immortal! "Is it," says an eloquent writer, "is it otherwise possible in the government of God? Shall the material thing, inorganic, inert, impercipient, move on in this wondrous perpetuity: and shall the soul which discerns its order and tracks its career, and detects its laws and speculates on its constitution, be swept away as nothing before it? Shall unconscious matter last, while the mind, to which alone its functions are subservient, which interprets its mysteries and reads them in the signature of God, vanish like the passing wind? Shall the knowledge and the thoughts of men be handed down in endless genealogy, teaching and inspiring the soul of other times; and shall the conscious creature which called them into being be blotted ignominiously from creation? Impossible! It cannot be, but that they, through the medium of whose thought we now gaze at the skies, witness elsewhere the excellence of their past toils, the triumphs of their studious meditations. Surely the Heavens which they deciphered, they behold with eyes undimmed by age, and minds yet yearning, but in a spirit of profounder adoration, to press forward towards vaster disclosures of the infinitude of God!"*

But it is amid the mechanism of the planetary system, properly so called, that the principle of gravity has achieved its noblest victories. Now, the *forms* of the planets became at once intelligible—round spheres into which attraction had compactly arranged their matter, only bulging or thrown out at their equators in proportion to the velocities of their rotations: now, was it seen why the Moon draws up the obedient waters, causing them to rise and acknowledge her power, and to flow round the world in tides: now, were the planets weighed in the nicest of balances, for they act on each other strongly or weakly just as their matter is greater or less, and from these *effects* we can precisely estimate the quantity of matter they contain: now, it was understood why the Moons of the larger orbs, revolve (as shown in Plate XI.,) so rapidly compared with the satellite of our Earth; for unless their attendants had rapid proper motions of their own, giving them energetic tendencies to fly off in straight lines through space, the immense attraction of these vast globes would draw them towards their bodies and absorb them into their mass: and now, was opened that interesting question, which first enabled the labors of Uraniburg to be fully appreciated—how far the ever varying actions of the planets on each other (for, be it remembered, Attraction is an influence issuing from every point; and a glance at Plate IV., will show from how many centres it streams forth and affects each orb), will deflect them from perfect elliptic paths, causing irregularities delicate and evanescent, which yet are no irregularities, but only finest proofs of the perfect mechanism of our system—of the all-pervading life which almost animates it and makes it one compact whole. Looking back through history at the course which realized these inspiring triumphs, two leading groups of men arrest the eye: the earliest, CLAIRAUT, D'ALEMBERT, EULER,—the first a man of finest genius, caressed by fashionable society, the darling of Parisian evenings; the second, a contemplative officer of high ambition, but satisfied with his cottage and its aged matron; and the last, perhaps the most rapid and fertile-minded man the world ever saw;—after whom that latter race arose, of which the tasteful and mild LAGRANGE, and the exhaustless LA PLACE, jointly occupied an easy chieftainship. Those illustrious men most worthily accomplished their mission, and wrought out the Law of Gravity to its minutest results; but still there is a careful distinction between *their* honors and those won by Newton. *They* well used the key; but that key was given them; they have explored the gorgeous temple; but its gates were opened by Newton's command. And on account of this peculiarity in his position, it can most safely be averred—not in consequence of the partialities of nationality, although few would blush in coupling the name of Newton with a feeling of honest pride—not in consequence of excusable partialities, but in obedience to the verdict of scientific Europe, that no man has yet appeared, nay, and that no man ever will appear to push our Countryman from his Throne.

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* Doubtless the writer of the foregoing paragraph recognizes the necessity of the *moral element*, to all rising and enduring glory. Doubtless he has seen among the tombstones of a mountain churchyard, humble records of struggle, of piety, resignation, and hope which burn with the promise of Life to come.

It is said that this great Geometer, after he had obtained possession of his Law, was employed in testing it by the aid of the evanescent effects above indicated—became quite abstracted and regardless of the concerns of life. A hermit, even in his earlier days, he was a thorough recluse; forgetful in the abstraction of his solitudes of the most palpable of those attentions to comfort which the conditions of our present being require. And who can marvel? Who else had a prospect like his—a sight for the first time of the actual processes of the creative mind! He was with one of the Almighty's IDEAS: and even when we think of the offices in which his great spirit was engaged, there comes—albeit we cannot thoroughly sympathize with him —a calm solemnity over the mind, a temporary resignation of terrestrial thoughts and cares, and a subjection of the soul to humility and veneration!

Strange thing the human mind, and pregnant in all its phases with matter for sad and strange reflection. Shortly after this middle period of life, while he seemed yet manful and strong, it is not to be doubted that a cloud fell upon Newton—a melancholy and desponding weakness, from which, during his long subsequent years, he never fully recovered. It is a mournful contemplation, that which, refers to the soul with Reason off its throne; and to *him* how mighty was the blank! If, as it seems, the struggle of thought was too strong for its material framework,—if comparative imbecility was the necessary consequence of contemplation so intense, of a vision of God's works so extensive and enduring,—then happy is the occurrence of that Rest, which, as it brings enlarged Opportunities, must also give augmented Powers.

When Newton died, a luminary sank in night. His body lay in state like the remains of kings, and the titled as well as the learned followed his bier—sorrowing. Honor could not be conferred on Newton by such manifestations, or a surer promise of immortality; for his name had already gone forth and become a dignity in the world. What more shall I say? Only this, that nothing requires to be said, and that all that could be said, were inadequate. Monuments in our Sacred Hall of Monuments have been inscribed to his name, but no Monument can contain it:—

> Nothing shall cover him but Heaven,
> And the eternal memories of his greatness;
> To which I leave him.

CHAPTER IX.

REMOTER CONSEQUENCES OF GRAVITY.

But the most important of the revelations we owe to the Law of Gravity, remains to be unfolded. Already we have seen it involving the entire solar system, acting towards it in its present state as a guide and conservator; but, as I have hinted in the introduction to this last division of our inquiries—it also does far more.

The causes of what are termed "perturbations" must now be distinctly understood. They arise from the mutual action of the planets—from the most various attractions exercised by these globes on each other: and the effect is to disturb the elliptic orbits, to alter and vary them. While Astronomy had advanced no farther than Kepler's laws, the planetary system appeared stable, and unthreatened by change or disaster; and even the first view of the Law of Gravity gave countenance to this notion: but when the existence of perturbations was revealed, Newton himself feared the instability of our scheme, and imagined that the Deity must directly interfere to preserve it. Groundless fancy! The Deity is no limited or imperfect Architect. His thought, which comprehends the Universe and all its destinies, is stamped upon its minutest part! It was perhaps the grandest discovery of the late generation, that these perturbations are PERIODIC or OSCILLATORY—that a planet, after leaving its regular or mean path for a certain time, returns slowly to that path, deviates from it on the other side, and again returns and passes to its former limit. Like a Pendulum these bodies move, now to one side of their mean line, now to the other; and although the oscillations in some cases occupy countless centuries, they are not less sure and fixed than those of the rod whose regulated motion marks a second of time. How striking is this new proof of the beauty and perfection of our little home-system! How reverentially have we been cared for! But our wonder will be farther excited on referring to the *source* of this stability and harmony. Thoroughly analysed, they are found to depend on those very laws or characteristics which I explained in the supplementary chapter of Part I.; laws also which do not enter *immediately* into the constitution of the principle of gravity.* If the planets had not revolved and rotated (their satellites obeying the same law) in the direction in which the Sun rotates; if their orbits had not been in the plane of his equator, and in shape approaching to circles, there had been no compensating power among the perturbations; for some might have increased indefinitely, and through defect of arrangement, the system been hurried to its ruin. How important, then, are those supplementary laws! Is it not manifest that provision for their existence must have been an essential element in the manner of our system's origin,—nay, that they may even show us the mode of its mysterious birth? Dimly, indeed, but assuredly, they have already performed this achievement: they have invited us into the regions through which the comets wander, and where I have told in another work, how Great Men have dared to tread: they unite together as parts of the same plan, matter most diverse, most variously modified, and they have raised our thoughts to an idea comprehending the previous state and after-destiny of the entire Stellar Creation.*

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* See page 144.

Thus, then, we close—stretching into INFINITY. Our System—small as it is, occupying a mere point in Space,—compact though it is, sustained apparently by its own laws,—rests yet upon the bosom of the Great Universe; and is not to be explained or comprehended but as a co-ordinate part of the mighty and mysterious WHOLE! And *so*, in this wondrous scheme of Existence, it is of the minutest Thing. Ask the history of a Pebble, inquire into the source of an evanescent Thought, and you are carried deeper and deeper, until through ever-deepening twilight the DARK is reached—those mists of MIRZA, which render farther investigation vain.

—Yet *how* is it, that Things are thus linked together? What are those LAWS, those Expressions of Order, whose existence is attested by external events, but nowhere explained?—Powers apparently environing all visible things, and superior both to Time and Space; so that when we contemplate them we feel the unchangeableness, the solemn stillness of Eternity—thus realizing the profound feeling of the poet, under whose thoughtful eye

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* I venture to refer, in further development of this engrossing subject, to a treatise recently published, "Views of the Architecture of the Heavens." The theory of the origin of our system there expounded, explains the greater number of those laws connected with it, which are *superior* to gravity; and I doubt not, will one day give inestimable illustration, even of such inquiries as the nature of the upheaving cause.

> Our noisy years seem moments in the being
> Of the Eternal Silence.

Dread Phantasms! Surely ye are part of the CREATIVE MIND: surely the faculty to cognize you, indicates a power to rise above Time, to link one's Being with what cannot be blotted out, as a wave is by that which succeeds it! Inspired by Hope—by confidence, REASON stretches towards you ever fondly, ever desiring to ADORE!

NOTES.

NOTE A.

KEPLER'S THIRD LAW.

The principle known by the foregoing name merits farther illustration ; but as that must be numerical I have thrown it into a note. As stated in the text, page 79, the law is, *the square of the times in which the planets revolve round the Sun as proportioned to the cubes of their mean distances from his centre :* so that the distances of two planets being known, and the period or year of one of them, the year or period of the other can be detected by a simple proportion, and *vice versa.* For instance, if the distance of the Earth from the Sun is accounted 1, that of Jupiter will be 5.2, now the period of the Earth is our terrestial year, what, therefore, will be the period of Jupiter ? The resolving proportion, counted in terrestial years, is as follows ;—

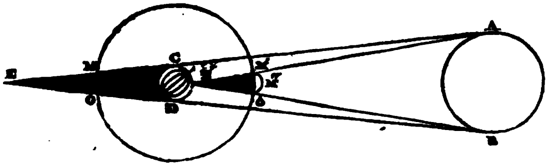
Cube of Earth's distance	: Cube of Jupiter's distance	= Square of Earth's period	: Square of Jupiter's period
1 × 1 × 1	:5·2×5.2×5.2	= 1 × 1	:11.86×11.86

from which it is deduced that Jupiter's period is 11.86 terrestrial years, which is withinthe merest trifle of his exactest period. In this example the Law will be clearly illustrated ; and the calculator may apply it to whatever other case he chooses.

NOTE B.

ECLIPSES.

It did not enter into my plan to explain all the special accidents or occurrences within our system: but the phenomena of eclipses are much too interesting and prominent to permit me to pass them without at least some brief notice. Suppose A B the Sun, C D the Earth, and the circle M O M′ the orbit of the Moon: it is manifest, first, that the Earth being opaque must always cast a shadow C E D, and also that the Moon being opaque must cast another dark shadow M″ E′; and



secondly, that when the Moon *enters* the dark shadow of the Earth she will be wholly obscured, although then at the phase of full moon; and that when she is right between the Sun and the Earth, her dark body will interrupt the view of the Sun enjoyed by the inhabitants of part of the Earth, either partially or wholly, causing solar eclipses of various characters and magnitudes. The phenomena of eclipses are extremely imposing, and in a physical point of view also most interesting,—offering questions far from being yet resolved. For instance, whence that bronze color of the Moon when even at the axis of the shadow, and where she ought to be wholly obscured or blotted out? Attempts were long made to explain this phenomenon by the supposed refraction of light through our atmosphere; but the cause is wholly inadequate: and we are forced to conclude that this luminary has some power of shining of her own, probably connected with those remarkable streaks or streams of light which issue from her Craters.

Eclipses of the satellites of the other planets arise from similar causes: how finely must they vary the scenery of such an orb as Jupiter! The eclipses of the Moons of this orb, have an aspect in scientific history which will always render them famous. By their means we discovered the velocity of the motion of light, now a most influential element in practical astronomy. Discrepancies were noticed in the times of the occurrences of these eclipses when seen from different parts of the Earth's orbit; from which it was inferred that they are not seen at the moment in which they do happen, but only after the light of the satellite had taken its proper time in traversing to us. The passing of light, any more than sound, is not instantaneous, but occupies a definite period; although it travels with the enormous velocity of 192,000 miles in one second of time.

The eclipses of these small bodies have also been employed by the mariner to compute his longitude or place at sea; and the finest results of theory have thus been brought into immeiate contact with the ordinary wants of man.

NOTE C.

BODE'S LAW OF THE DISTANCES.

A very curious relation among the distances of the Planets from the Sun was discovered by a German Astronomer, not from theory, but from a mere inspection of the numbers representing them. It is *that the intervals between the orbits of any two planets is about twice as great as the inferior interval, and only half the superior one; i. e.* the interval between the orbits of the Earth and Venus is double that between Venus and Mercury, and only half the distance between the paths of the Earth and Mars. Professor Challis of Cambridge has recently extended this principle to the distances of the satellites; so that, although still somewhat indefinite, it is unquestionably an essential part of the arrangements and mechanism of the system; and will rereceive elucidation when we are able to take a more thorough view of our system.

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This work. written by J. P. Nichol, LL.D., F. R. S. E., professor of Practical Astronomy in the University of Glasgow, has created a great sensation in England. It displays more research, and is a more perfect work, than anything of the kind heretofore published. In a very short space of time three large editions of the work were published in London. This induced H. A. Chapin & Co., 138, Fulton-street, to publish the work here. It is illustrated by a great number of plates. Notes and a glossary have been added by the American publishers.

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Rarely have we met with a work of so much merit; and it is inferred that it has been fully appreciated abroad, from the fact that it has already passed through three large editions there. The style of the author is that calculated to popularize the subject, a circumstance which must insure for it a rapid sale in this country. Hitherto the late discoveries in firmamental nebulæ have been confined to more elaborate treatises and scientific publications; and, as a consequence, have been little read and but indifferently understood, particularly in this country. It has been the aim of Professor Nichol, therefore, to present the subject in its most attractive and comprehensive form; and the ability with which he has accomplished this object can better be learned by a perusal of the work than by any remarks of our own. For ourselves, however, we may say, that the volume possesses extraordinary interest, both from the nature of the subject and the style in which it is treated. The language is indeed sublime, whilst the facts he discloses are startling and intensely interesting.

From the New York Express.

This work is beautifully illustrated by numerous plates, and is calculated, both from the nature of the subject and the style of the author, to create no slight sensation among readers of all classes.

Little has been known in relation to the *nebulæ* and the late discoveries in Astronomy: this work, therefore, comes to us opportunely, and crowded with particulars of the highest interest. It is impossible that one can read it without being impressed with its importance, or without being inspired with feelings of surprise and admiration. The learned author has made the subject plain and familar to the minds of general readers, by communicating the extraordinary facts which he treats in a series of letters addressed to a lady, and by avoiding technical language; so that all will be equally interested in the remarkable truth, as well as the style of the work. The volume, though small, is published at half the price of the English copy, with additional plates, notes, &c. In conclusion, we would commend it to general perusal, for it cannot be otherwise appreciated.

From G. Bush, Professor of Biblical Literature in the N Y. University.

I have attentively examined the work entitled, "*Views of the Architecture of the Heavens*," by J. P. Nichol, LL.D., F. R. S. E., of the University of Glasgow, and I cheerfully avail myself of the opportunity to say, that I consider it one of extraordinary interest and merit. No treatise of the kind has fallen in my way combining such important views upon the same subject; and, whether viewed as a work of science, embracing new and surprising phenomena in nature, or as a production of talent, it is alike remarkable.

I cannot too highly recommend it to readers of all classes as presenting the most interesting views of creative power, the latest discoveries in the heavens, and the most perfect, as well as the most plain and glowing description of the nature, origin, and probable destiny of worlds.

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The scientific character of this book, as announced by the title, may deter the common reader. We inform him, therefore, that science is here illustrated by such familiar objects, and such pains are taken to render plain, easy, and intelligible that which would otherwise be abstruse, that a very slight knowledge of the principle of astronomy, and of the technical phraseology peculiar to it, is requisite, to enable us to read the work with understanding. At the same time, while the style and the modes of illustration are eminently popular, the publication deserves not to be regarded as one of those superficial productions, which so simplify knowledge as really to render its possessor a mere simpleton. This is a work of sterling merit, and communicates information that is possessed by few. Such is the magnificent nature of the subject with which it is concerned, and such the stupendous character of the truths which it developes, that the man who devotes himself to the study of astronomy and exhibits no tinge of enthusiasm, must be destitute of one of the ordinary qualities of the human mind. The title of the book is significant. It is not a "Geography of the Heavens," but "Views" of its "Architecture." It does not regard the phenomena of the sky as objects presented on a concave surface, but examines them according to their relative distances, and exhibits stupendous *frame work* of the whole fabric. From it we form some idea of the *shape* of this fabric, and are astonished to learn that another similar fabric has been dimly discovered in the remote regions of space. Whether immensity is crowded with such systems, each including its millions of suns, with their attendant minor systems of planets, asteroids, and comets, is left to conjecture.

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We are glad of the opportunity of noticing the republication of this work in this country. It is a volume remarkably caculated to show the religious and even devotional tendencies of true science. It is difficult to conceive how any one can contemplate the disclosures it makes of the vastness of creation without being awed into a posture of profound adoration. Not merely the earth which we inhabit, but the entire planetary system to which we belong sinks away to absolute insignificance when compared, not with the *conjectural*, but with the *ascertained* numbers, magnitudes, distances, and periods of the bodies which people the regions of illimitable space! These results, it is true, are some of them presented in the form of *theories*, which cannot be said to be demonstratively established; but they are not a whit more strange than the undeniable *facts* upon which they are built. That it is a book of *cosmogonies* is certain; but it is Herschell's telescope and not Professor Nichol's pen that has achieved the creation.

We know not, in the brief notice which our limits allow, how to *begin* to state the matters of interest that are brought to view in this volume. What must the end of a treatise be which commences, as one of its lowest positions, in showing that our solar system belongs to the Milky Way, and that the Milky Way itself is merely one of an infinitude of similar clusters, though of every imaginable and unimaginable variety of form, scattered through the measureless blue depths of ether?

Yet this is the humble starting point of the author; and as he travels onward to the boundless fields of Nebulæ, in which the telescopic eye almost discerns the actual generation of suns and systems, it is but an entertainment by the way, to show us groups of double, triple and quadruple stars, eddying about each in mystic circles,; and what is yet more astonishing—of *variegated colors!* affording to their dependent worlds now a *blue*, now a *red*, now a *purple*, and now a *yellow* day! All this, and vastly more, enter into the surprising revelations of this work. Of the book, as a book, we feel as if we had positively nothing to say. The subject is all in all—grand—engrossing—overwhelming. We *conclude*, as an after-inference, from the effect produced, that the mode of presentation is happy—that the book is well planned and well executed; but the mind is so carried away with the *plan* and *execution* of the Universe, that it has scarcely a thought to bestow upon the writer.

From the Christian Intelligencer.

We had noted several passages to extract; but, upon reflection, we perceived that no quotation would give any adequate idea of the volume. One short paragraph must suffice. It is at the close of Letter III., page 34.—" *The Universe!* Where are we, after all, but in the centre of a sphere, whose circumference is 35,000 times as far from us as Sirius, and beyond whose circuit boundless infinity stretches unfathomed as ever. In our first conceptions, the distance of the earth from the sun is a quantity almost infinite. Compare it with the intervals between the fixed stars, and it becomes no quantity at all, but only an infinitessimal. Now, when the spaces between the stars are contrasted with the gulfs of dark space separating firmaments, they absolutely vanish below us. Can the whole firmamental creation, in its turn, be only a corner of some mightier scheme—*a mere Nebulæ itself?* Probably *Coleridge* is not in error—' It is not impossible that to some infinitely superior Being the whole universe may be as one plain—the distance between planet and planet being only as the pores in a grain of sand, and the spaces between system and system no greater than the intervals between one grain and the grain adjacent!' "

We most earnestly recommend the attentive scrutiny of this charming volume to all Students, and especially to all Theologians—hereby certifying for their benefit; that unless they comprehend something of the " *Architecture of the Heavens*," according to Professor Nichol's magnificent display of its ineffable wonders, they are not qualified to expound the first verse of the 19th Psalm. Therefore, " get wisdom, and instruction, and understanding!"

From the American Biblical Repository.

The wonderful discoveries of Modern Astronomy claim the attention of all classes. Though intensely interesting to the man of science, they can be clothed in a popular form. In proof of this we have only to appeal to the work before us. While most of these discoveries, particularly those revealed by the late researches in firmamental nebulæ are confined to learned and elaborate treatises, this volume, the publishers justly remark, " is indited in plain but glowing and elevated language, comprehended by, and alike inspiring to all." The author takes us into the very centre of the mighty frame-work of the universe; and makes us acquainted with those distant bodies—majestic and awful for their vastness—which are known to us only as *nebulæ*. Those who have paid the least attention to the science of Astronomy will have no difficulty in following Prof. Nichol; and they may hereafter look at the heavens with something of the feelings of the accomplished Astronomer.

We rejoice that the execution of this plan has fallen into such hands. The eminent talents of the author, and his experience as a practical Astronomer would lead us to expect a work like the present. Few could have prepared one so interesting, and at the same time so trustworthy.

It is due to the publishers to add, that the maps and plates are beautifully executed; the notes and glossary, by Mr. Chapin, have been diligently prepared.

From the New York Evangelist.

About one hundred copies of this work were imported, and although their price was over four dollars, they were immediately sold. An American edition has now been published, with some additions, to make it more valuable to the common reader. The price is now one dollar and fifty cents. The great number of plates which it includes, is the reason of the price being so high as it is even now.

The Professor has taken the investigations of former astronomers, and especially those of John Herschel, as the foundation of his themes, and speculations. Although he introduces but little which was not previously suggested by Herschel, he has followed these suggestions out with more boldness, and has invested the whole with language at once fraught with intensity, meaning, and poetic splendor. Such is the sublimity of conception, the beauty of diction, and the excitement of the intellectual excursion which he compels the reader to take, that he does not let him have any repose until he arrives at the last page. We commenced reading it at about four o'clock, P. M., it did not let us go to rest until two o'clock in the morning. After an early breakfast, we begun where we left off, and completed the whole before twelve. One inducement to infringe on the usual hours of slumber, was, that our study looked out upon a splendid southern sky, in which the ethereal realms so eloquently described, were unfolded to our view. Could we have had one of those powerful telescopes which have been recently invented, the enjoyment would have been complete.

In reading the work, it is important to hold in the imagination with the reins of a discriminating judgment.

There is one reflection, which continually crowded upon the mind while on the wing, that the grandest themes of astronomic science could awaken no emotions of reverence towards the Eternal Creator, which the language of revelation is not perfectly adequate to express.

The work will undoubtedly have a rapid circulation, as it is eminently adapted to popular reading, and is of such a nature that every one who has read it, will be anxious to have his neighbor read it also.

From the Arcturus.

This an excellent book, not only for what it contains, but for what it suggests. The thought is at all times true and pointed; and the work produces as startling effects on the imagination of the reader, by the mere statement of facts, as the highest romance or poetry does by artful effect. The additions by Mr. L. D. Chapin are important, and increase the value of the American reprint. An extensive circulation of the book must enlarge the sphere of contemplation and reflection in our community, and cause many to regard the midnight heavens with more reverence than ever.

From the Louisville Public Advertiser.

We are indebted to the courtesy of the publishers, for a copy of one of the most interesting works that has for a long time fallen under our observation. It is comprised in a series of letters to a lady, written by J. P. Nichol, LL.D., F.R.S., Professor of Practical Astronomy in the University of Glasgow, and contains, in the most elegant, and yet plain and practical language, the author's "*Views of the Architecture of the Heavens.*" From the comprehensive nature of the author's design, and the wide field over which his observations range, we should suppose that, instead of *one* volume, a dozen at least would be required in the elucidation of the many branches of the science of Astronomy upon which he has treated. Yet still, all is plain to the most common understanding—nothing is obscure—and the reader will turn from his brief elucidations of each topic, wiser than when he set out, yet filled with deeper admiration of the works of the Creator, and impressed with the truth of the dying exclamation of the great LA PLACE:—"That which we know is little—that which we know not is immense."

From the Olive Branch.

This work has been noticed by many of our contemporaries in the highest terms of praise; and if, by our recommendation, a single copy should find its way into the hands of some student, and be read, we should feel that we had accomplished something for the increase of rational intelligence. It contains the latest discoveries in the planetary system, with the most profound and sublime views of the creation and probable destiny of the Universe.

From the Evangelical Magazine.

If the readers of the Magazine and Advocate desire to obtain sublime views of Astronomy in its most profound and highest sense—if they wish to obtain knowledge of the glory of the Almighty, displayed in the boundless regions of space, unfolding facts which are grand beyond conception—then let them procure a copy of the above work, and read it,—not once only, but twice and thrice; and they will rise from the perusal, impressed with vaster and nobler understanding of the works of Him, who liveth forever. The book is written in a style of great purity—its language is beyond expression, excellent. And yet it is so clear, and the facts which it conveys are so simply detailed, that they are brought within the reach of the most common reader.